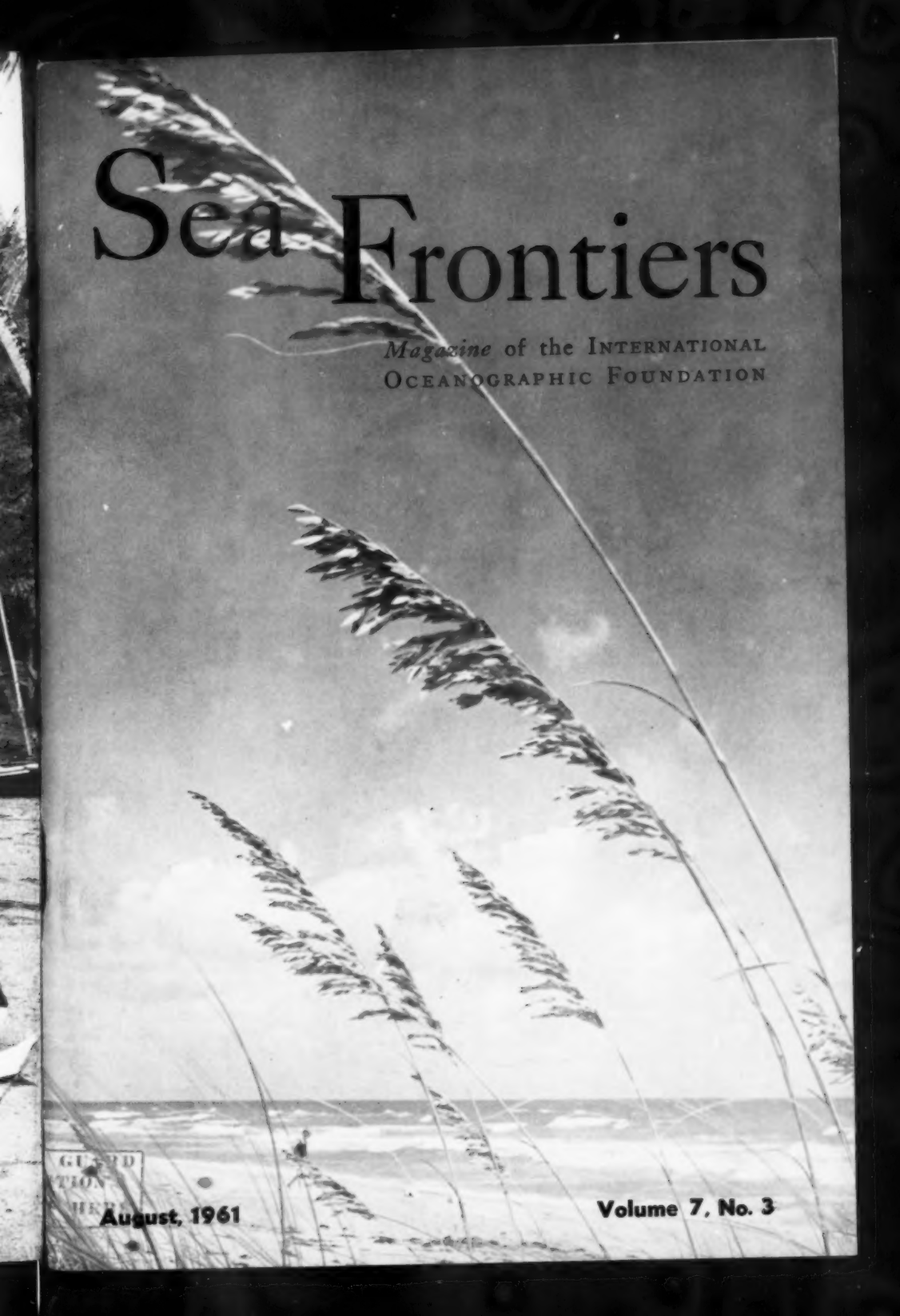
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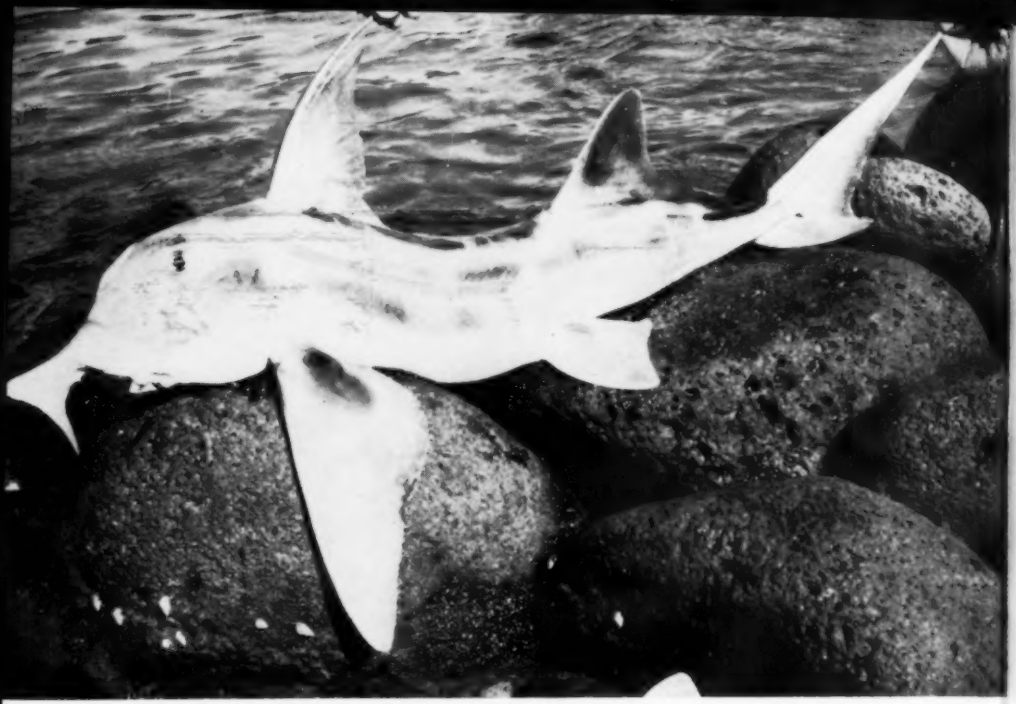

PREHISTORIC CREATURE? *Merely a fish of unusual appearance. It is known as an Elephant Fish* (Callorhyneus milii) *and is not uncommon in the waters around Australia. The strange appendage on the snout is a paddle-like trunk with which it locates the shellfish and small crustaceans on which it feeds.* (Anglers' Digest, *Sidney, Australia*)

FRONT COVER. SEA OATS. *A characteristic and attractive component of seashore life is the sea oat* (Uniola paniculata). *This restful scene was captured near Jensen Beach, Florida. (Charles E. Lane)*

BACK COVER. NEW LONDON LIGHT. *Despite the scars left by raw winds and a biting surf, this old lighthouse stands proud and erect on the shore at New London, Connecticut. It is just one of the many interesting old lighthouses which dot our northeastern coast, epitomizing the quiet and dignified charm of New England. (Connecticut Development Commission)*

SEA FRONTIERS

Magazine of the INTERNATIONAL OCEANOGRAPHIC FOUNDATION

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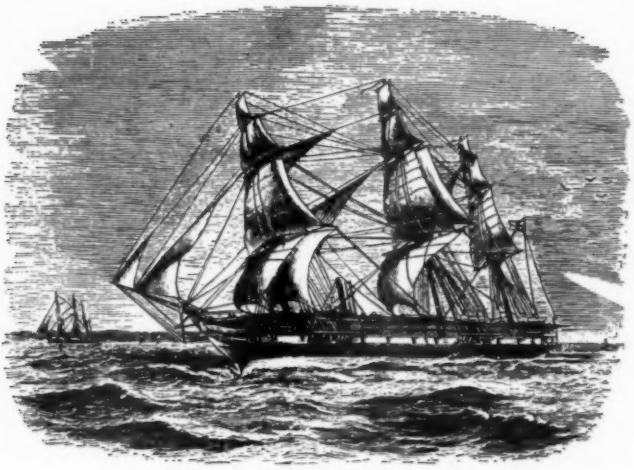


VOLUME 7, NO. 3 AUGUST, 1961

THE SINISTER BARRACUDA, *here hovering in the clear, shallow water of Dry Rocks, Key Largo, Florida, constitutes a threat not only to bathers, but sometimes to those who eat its flesh. (Robert E. Schroeder)*

Ciguatera: Tropical Fish Poisoning

By JOHN E. RANDALL
Contributing Editor, Sea Frontiers

ON MAY 8, 1949, fifty-seven Filipinos at Saipan in the Mariana Islands sat down to a meal of a huge moray eel, said to have been about one foot thick. The moray was fresh and had been cooked for thirty minutes. As the fish was eaten, a scratchy sensation in the mouth and throat was noted. About twenty minutes later the men experienced tingling and numb sensations about the lips and tongue. Approximately thirty minutes after the ingestion of the moray, some were unable to talk. The entire group became alarmed and was taken to a dispensary where each

LIKE A BANDED SNAKE *is the moray eel, and its flesh can be as deadly as a snake's fangs. This 2½-foot specimen* (Gymnothorax undulatus) *was caught in the Gilbert Islands, central Pacific. A single large moray once poisoned 57 men on the Pacific Island of Saipan, resulting in the death of two of them. (John E. Randall)*

of the sufferers was given a gastric lavage.

In spite of this, the condition of the men worsened. Most vomited and by the next day all experienced tingling of their hands and feet. The respiratory chest muscles showed progressive inability to function. Many of the men had convulsions. Eleven became comatose, and two died.

Humans, Chickens and Rats Victims

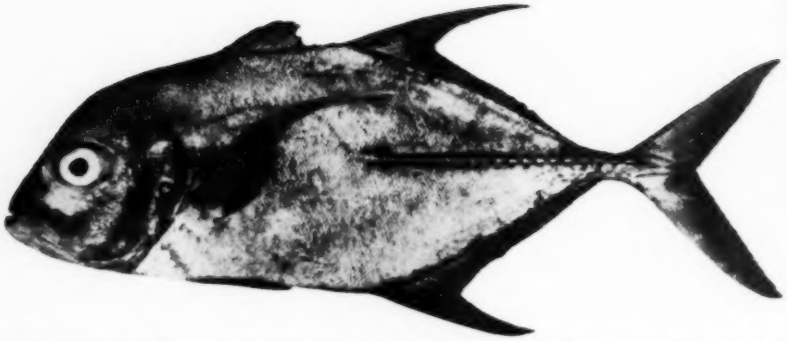
At Terre-de-Bas, Saintes Islands in the Lesser Antilles, a total of twelve persons of two families were poisoned on July 11, 1951 by eating a large barracuda. It was eaten within a few hours of its capture and appeared normal in all respects. Thirteen chickens which pecked at the material vomited after the meal and a dog which ate the fish's intestines died.

The next day rats which may have fed on offal from the fish were found dead. Doctors were helpless as the illness progressed, and the victims suffered terribly. Three died, and another went insane three months later.

Poison World-wide in the Tropics

The unfortunate people poisoned by the moray eel in Saipan and those who ate the barracuda 11,000 miles away in the French West Indies suffered from the same toxemia, a neurotoxic disorder called ciguatera. Analyses of the symptoms of these and other victims in the tropical Atlantic and in the tropical Indo-Pacific region fail to reveal any great differences; thus ciguatera may be regarded as pan-tropical in occurrence. It is known from some subtropical regions such as southern Florida, but never from temperate zones.

If we assemble what appear to be well established facts about ciguatera —a task admittedly difficult because fact and fable are so inextricably mixed—certain features emerge. Perhaps the most striking is that ciguatera does not occur at any particular place or time. Toxic fishes are not found over a broad area but are usu-



WIDE-EYED AND INNOCENT-LOOKING, *but the black jack* (Caranx lugubris) *can be a poisoner of man. Several other jacks of the same genus, such as the horse-eye and the yellow jack, have evil reputations with respect to ciguatera, mysterious fish poisoning. (John E. Randall)*

ally in small sectors.

In reference to poisonous fishes at the Turk Islands in the Bahamas, Mowbray wrote, ". . . the fish from one side of the islands were much more dangerous than those on the other. This seems entirely preposterous, especially in the case of Grand Turk, an island only 1½ miles wide by 6 miles long, but such a statement is met with over and over again in articles on West Indian Ciguatera."

In Moorea, in the Society Islands, a ½ mile section of shore reef at the entrance to Papetoai Bay was considered by local Tahitians to harbor poisonous fishes. Even the edible sea urchin, *Tripneustes gratilla,* was said to be toxic. The author collected fishes and a specimen of *Tripneustes* from the area and shipped them frozen to A. H. Banner, Director of the Hawaii Marine Laboratory, who found some of the fishes and the sea urchin toxic when fed to mongooses.

A toxic area may become safe after a long history of containing poisonous fishes, and vice versa. Gilbertese natives informed the author that there were no poisonous fishes at Onotoa Atoll in 1951, but two years previously a reef area at the anchorage in the pass contained toxic fishes.

Related To Military Vessels?

There is also the example of certain of the Line Islands in the Central Pacific. Poisonous fishes had been unknown except for the puffers (which cause a different type of fish poisoning) until after armed forces arrived during World War II. Then serious outbreaks occurred on Fanning and Christmas Islands. Washington Island, which has never had a poisonous fish problem, was not visited by military vessels during the war.

Poisonous fishes are reef fishes, or fishes which prey upon reef fishes. Offshore fishes, deep-sea fishes, fishes near river mouths, or fishes of sand or mud bottoms do not cause ciguatera.

Watch Out for the Big Fish-eating Fishes!

Not all reef fishes are capable of producing illness when eaten. In all areas where poisonous fishes are known, a few species only are responsible for most cases of ciguatera. There are many others which only occasionally or rarely cause ciguatera. Some always seem to be safe to eat. The worst offenders are the larger predaceous species like the barracuda *(Sphyraena barracuda)*, jacks *(Caranx* spp. and *Seriola* spp.), certain of the snappers *(Lutjanus* spp. and *Lethrinus* spp.), groupers *(Plectropomus* spp. and *Mycteroperca* spp.), and moray eels *(Gymnothorax* spp.). These fishes are predominately or entirely fish eaters.

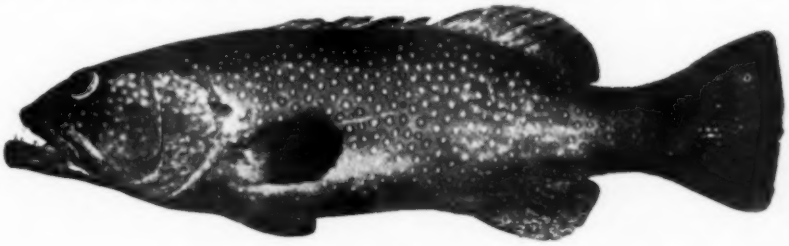
Among those predaceous fishes which feed partly on fish and partly on other animals such as crustaceans, there appears to be a relationship between poisoning and the amount of fish in the diet. Of the fishes which occasionally cause poisoning, we find other distinct food-habit types. Mollusk-feeders such as the hogfish *(Lachnolaimus maximus)* of the West Indian region and the sparid fish *Monotaxis grandoculis* of the Indo-Pacific and sea urchin-feeders such as the queen triggerfish *(Balistes vetula)* of the tropical Atlantic have been responsible for typical cases of ciguatera. In very poisonous sectors plant-feeding types, such as parrotfishes and surgeonfishes, may be involved.

Within any species, it seems generally true that the larger the fish, the more prone it is to be poisonous. Nearly all of the local people in a poisonous area will eat small barracuda of less than about three pounds. Few, if any, will chance a large one.

Tingling Sensations

Fortunately, most persons who become ill with ciguatera survive. Probably many more who become sick, especially if not severely, never suspect that the fish they ate caused their illness. While in the Tuamotu Archipelago, the author was poisoned by eating a small amount of a grouper *(Plectropomus leopardus)*. The primary symptoms were weakness, especially of the lower limbs, and diarrhea; these might not have been

BLUE-SPOTTED GROUPER (Plectropomus truncatus), *a fish to beware of in the tropical Pacific. A near-relative of this fish poisoned the author and two associates, even though it was eaten absolutely fresh. (John E. Randall)*



NOBODY WANTS THIS FISH *in the Virgin Islands! However, closely related to this amberjack is the California yellowtail which never causes fish poisoning. The latter lives in relatively cold water where the tropical seaweed, believed to produce the poison, does not grow. (John E. Randall)*

attributed to the eating of the fish were it not for the more severe and typical symptoms of two associates who ate the same grouper.

The most common symptoms listed for ciguatera are weakness, diarrhea, tingling or numbness of the lips and hands and feet, nausea, joint and muscular pain, poor coordination of voluntary muscular movements, difficulty in breathing, burning urination, itching, and confusion of the sensations of heat and cold. One U.S. Navy officer poisoned in the West Indies was observed blowing on his ice cream to cool it! Probably the most diagnostic symptoms are the tingling sensations in the hands and feet, frequently described as like "pins and needles" or "electric shocks," and the feeling of heat when cold objects are touched.

The gastric distress of ciguatera is usually of short duration, but the neural symptoms may last for many weeks. Various persons in the Society Islands informed the author that some reef fishes not poisonous to other people will nevertheless increase and prolong the tingling sensations in the extremities of those already poisoned and recovering. In reference to ciguatera in the Caribbean, a fisheries officer wrote that the effects may last for three months, and as long as the symptoms are present, any fish eaten will make them worse.

Ciguatera Not from Spoiled Fish

Some persons have voiced the opinion that there is no such thing as being poisoned by eating a fresh fish. Fish poisoning, they say, comes from a spoiled fish. Those who believe this notion are usually persons who have eaten big barracuda or other fishes of evil reputation all their lives without getting sick. The man who caught a 15½ pound barracuda off Key Largo that put five Floridians in the hospital on December 10, 1960 was such a person. He was quoted in the *Miami Herald* as saying, "I've been eating 'cuda for twelve years and I thought that poison business was just talk."

Undeniably, many persons have become ill from eating fishes spoiled by

bacterial action. This seems especially true of the tunas and their allies which spoil rapidly in tropic heat and cause an allergy-like poisoning similar to the effect of histamine. But it is equally true that a very fresh fish can make a person sick when eaten. In the case of the grouper which poisoned the author and associates the fillets were cut and cooked immediately after the fish was caught.

Many Astonishing Theories

Some astonishing theories have been proposed to explain the cause of ciguatera. One, for example, holds that poisonous qualities are caused when fishes are left in moonlight. Another more reasonably suggests that the poison is an inherent property of the flesh or other part of the fish. This is true for the poisonous puffers but not for fishes producing ciguatera, because it fails to explain why a fish is poisonous in one area and not another.

Several authors have tried to establish a case for the existence of a definite season for ciguatera, usually with the suggestion that the toxicity is tied to the development of the roe during the spawning period. A comparison of many cases of ciguatera within an area occurring in different months soon demonstrates that a fish can be poisonous at any time of the year.

Copper To Blame?

Most writers accept the concept that something in the surroundings of the fish is responsible for the poison. There is a persistent belief that a chemical substance contaminates the area, thus resulting in ciguatera. Copper is most frequently implicated, perhaps because wrecks of copper-bottomed ships and naturally-occurring copper deposits, such as the one on Virgin Gorda in the Virgin Islands, have been associated with poisonous fishes. But it is difficult to explain why poisonous fishes are found away from the source of the chemical, or why some and not all of the fishes in a contaminated area are poisonous.

Ross, a medical officer in the Line Islands, stated that poisonous fishes were first noted at Fanning Island four months after war materials were dumped by the American army in 1945. The fishes were poisonous in the vicinity of the dumping site. He thought that the fishes became poisonous by feeding on plankton which had absorbed the poison from the deterioration of the metals, especially copper, of the war materials. But plankton-feeding fishes or fishes preying only upon plankton-feeding fishes do not cause ciguatera.

Plant Life Suspected

It seems more plausible to assume that something a fish might eat from the bottom is producing the toxin. In an article in the *Bulletin of Marine Science of the Gulf and Caribbean* (1958), vol. 8, no. 3, the author put forth the theory that the basic cause is a benthic blue-green alga (some of these sea plants are already known to be very poisonous). Origin of the poison from plants seems likely because fishes which feed exclusively on seaweed are known to be poisonous.

One outbreak of fish poisoning in the Hawaiian Islands was caused by a shipment of surgeonfish *(Acanthurus triostegus)* from the Line Islands. This species is known to feed only on fine threadlike algae. It was suggested that the poisonous seaweed is a pioneer plant which is among the first to start growing when a new surface is exposed in the sea. With this concept in mind, the localization of poisonous fishes can be explained. At Fanning Island new surfaces were provided by the dumped war materials and also by breaking up of coral at the anchorages during the war. The manager of the copra plantation at Fanning wrote in a letter in 1958 that "the really deadly areas were the only two places where military vessels can anchor." The damage to coral in these areas from anchors and cables could be "clearly seen from the surface as large white scars."

Off the Steep Side

Here, also, may lie the reason why one side of a small island is toxic and another is not. It is the steep side

FINGER OF SUSPICION *points at the red snapper* (Lutjanus bohar), *implicated more often in fish poisoning in the Indo-Pacific than any other fish. Dr. A. H. Banner (center), and associates, Drs. Helfrich (left) and Sasaki are conducting research on ciguatera at the Hawaii Marine Laboratory. (Masao Miyamoto)*

NOT GUILTY! *Since copper was once dug from Coppermine Point, Virgin Gorda (note ruins in lower center), fishes were believed to be poisonous because of "copper banks" presumed to occur off the headland. Copper, however, does not cause ciguatera. Beef Island and Tortola, of the British Virgin Islands, may be seen on the horizon. (John E. Randall)*

of islands like Turk in the Bahamas which harbors poisonous fishes. On a steep surface wave action and boring organisms cause a steady erosion of the rocks. The southeastern portion of the Saba Bank in the Lesser Antilles is notorious for poisonous fishes. This part of the bank is also steep The region off the copper mines on Virgin Gorda is precipitous. Furthermore, rubble was supposedly thrown into the sea when the mines were in operation. Wrecks of ships provide new surfaces and replenish this as they break up.

The poisonous sector in Moorea is

bisected by a stream bed which is normally dry, but during torrential rains it carries huge amounts of fresh water to the sea which would kill marine plants in the vicinity and permit growth to begin anew. The toxic organism is probably not tolerant of water of low salinity.

Poison produced by plants may reach man by several biological routes or food chains. The alga may be eaten by a fish and this fish by a larger fish. Or it may be eaten first by a snail, or sea urchin, or other invertebrate. As the toxin passes from plant through various animals to man, it retains its integrity, thus it is probably a small molecule.

Not Toxic to Fish Themselves

It is important to note that the poison does not harm fishes. The deadly barracuda from Key Largo, for example, was described as a "hard fighter." And probably nothing ailed the large moray eel that poisoned the fifty-seven Filipinos at Saipan. Moreover, Takata has shown in an experiment in Hawaii with captive poisonous fishes that the poison does not disappear from the flesh when fishes are removed from the danger areas. Consequently, fishes remaining in such areas would continue to accumulate the poison.

This accumulation is evident from the fact that large fish are more deadly than smaller ones of the same species. And it explains why the large predaceous species are the worst and often the only offenders. When a barracuda feeds on a surgeonfish, it obtains in a single meal a lifetime of poison stored up by this plant-feeding fish. Each time a predator eats a fish or invertebrate containing poison, its deadly potential is increased.

There is a tendency to consider fishes as either poisonous or wholly nonpoisonous. The criterion of toxicity is whether a human or some other mammal becomes sick when a fish is eaten. If there are no symptoms of ciguatera when a fish is eaten, it is assumed to be nonpoisonous. However, a person recovering from ciguatera may eat a reef fish that causes no distress in other persons but which brings about a return or intensification of his symptoms. The fish evidently contains enough toxin to raise that already present in his system to the danger level but not enough to make persons ill who have not eaten poisonous fish shortly before.

Test for the Toxin Needed

At the present time there is no cure for persons suffering from ciguatera. Doctors can treat it only symptomatically. An effective anti-toxin is the obvious need for treatment.

The importance of ciguatera goes beyond the purely medical aspects. Many nonpoisonous fishes are denied to humans or domestic animals as food because of fear of toxicity. Sections of reef with a reputation of harboring poisonous fishes are not fished, whereas harmless areas may, as a result, be overfished. Every effort should be made to develop a simple, rapid, sensitive test to determine whether a fish is toxic before it is sold or eaten. Silver coins, by

the way, do not blacken when cooked with a poisonous (but fresh) fish. Nor do houseflies avoid a poisonous fish. These are old wives tales.

The logical first step in the development of a test is the chemical analysis of the poison. Attempts to isolate it have not been successful, although some progress has been made, notably at the Hawaii Marine Laboratory. It is now known that the poison is probably a fatty substance, for it is soluble in fat solvents like ether.

Once a sensitive test for the toxin is developed, the marine biologist will have an important tool with which it should be possible to solve one of the sea's many mysteries — the real origin of ciguatera.

"White Gold" From the Ocean Floor

Twenty centuries are witness to the uses of diatomite, the lightweight, hard-packed remains of microscopic diatoms which drifted, billions of years ago, from the upper zone of the seas to the ocean and lake floors to form today's "white gold."

Its lightness induced the Emperor Justinian to employ it on the gleaming dome of Haighia Sophia in Constantinople in 532 A.D. More recently Albert Nobel, in 1870, created dynamite by soaking nitroglycerine into diatomaceous earth.

Very Versatile

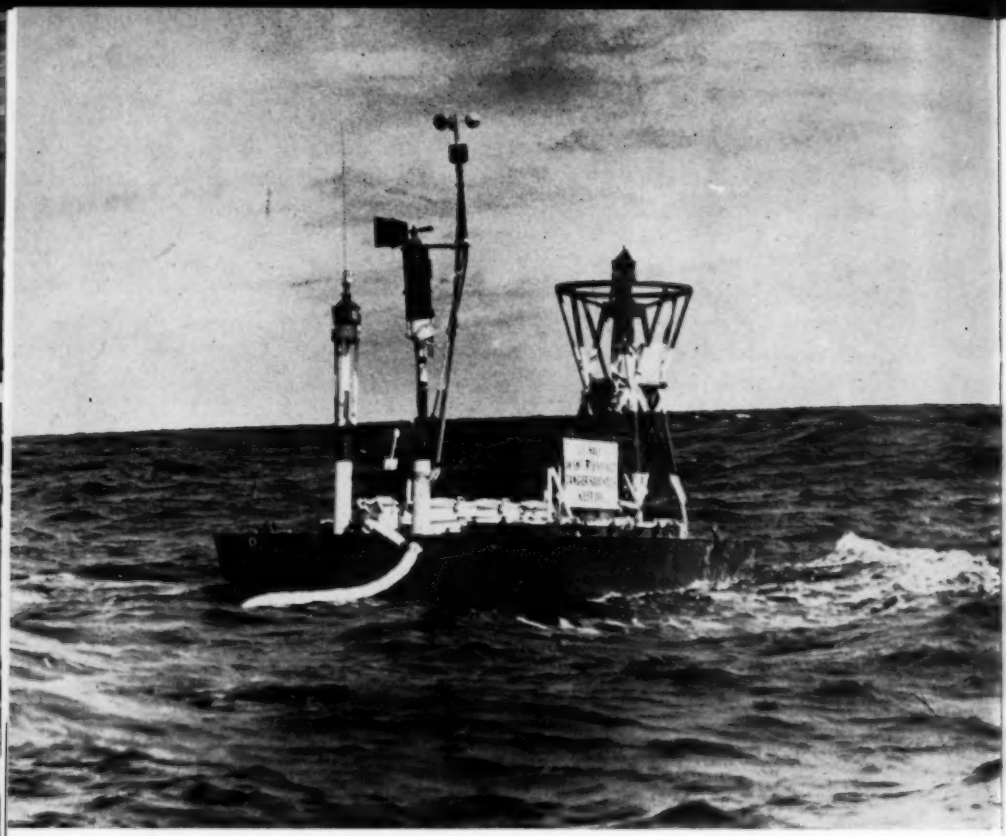
Modern industry has devised numerous uses for diatomite because of its light weight in relation to bulk, its tremendous surface area per pound, its high absorptiveness, its suspension properties in liquids and its fireproof qualities. When formed into straining cakes, it is porous enough to permit liquids to flow freely, while straining out bacteria through its lacy particles. Drug firms use it to filter antibiotics.

It insulates blast furnaces and strengthens highway concrete. The light-diffusing properties of the diatom's skeletal structure produce flat and semi-gloss finishes in paint, and increase the opacity and brightness of paper. An exotic and more publicized use is in a new cigarette filter.

Smallest Sea Life

Diatoms, belonging to the group of plants called algae, are the smallest form of sea life, forming the basic diet for plankton and thus initiating a fish food-consumption cycle ending on man's dinner table. Diatoms themselves grow by extracting minerals from the sea around them, including pure silica for their skeletons, and by absorbing light from the upper or epipelagic life zone, in which they live primarily.

The skeletons sinking to sea and lake floors in earlier eras resulted in huge deposits of packed, hard rock. Today these old deposits are mined or quarried in California, Nevada, Oregon and Washington. France, Finland and Denmark also have large deposits but little is known about Russia's supply, believed to be enormous. Evidence of its utility is the increase in production of 20,000 tons, in 1900, to a known 750,000 tons in 1957. Selling price—$40 a ton.



THE NAVY'S NEWEST RESEARCH *in weather forecasting is represented by this completely automatic weather eye. Equipment on this unmanned boat-type buoy broadcasts all atmospheric conditions every six hours. Anchored in the Gulf of Mexico last September, it gave ample warning of the approaching wrath of Hurrican Ethel. (U. S. Navy)*

Automatic Weather Eye

By GARDNER SOULE

THE BEST WAY to get weather information from points at sea may soon prove to be not Texas Towers or weather ships but a boat-type, unmanned buoy.

The boat-type buoy, securely anchored, contains a radio transmitter that every six hours broadcasts the air temperature, water temperature, atmospheric pressure, wind speed, and wind direction.

Hurricane Alarm

Last September 14, such a buoy became the first unmanned weather station in history to warn folks of an approaching hurricane. This experimental aluminum model, weighing

about 20 tons, is operated by the U.S. Bureau of Standards and monitored by the U. S. Weather Bureau. It is part of a research program for the U. S. Navy, by Texas A. and M. College.

The buoy was anchored 300 miles south of New Orleans in the Gulf of Mexico when, on September 13, it broadcast information that showed a very low pressure point and easterly winds of 22 knots.

By 6:30 the next morning winds were in excess of 26 knots, pressure was continuing to drop, and winds were westerly. All this indicated the approach of an exceptionally heavy storm.

People Warned in Time

The U. S. Weather Bureau, receiving the information from the buoy at Kingsville, Texas, and Fort Lauderdale, Florida, announced that Hurricane Ethel was about to hit. People along the coast accordingly were able to move out of danger areas.

This buoy is a strictly experimental weather observation unit, designed for use from a fixed position. It was developed by Dr. William Hakkarinen, of the U. S. Bureau of Standards, Washington, D.C., and was produced under the direction of Dr. E. F. Corwin and his associates in the Aerology Division, Bureau of Naval Weapons.

As in the case of all "first" experiments, it has caused a lot of trouble in the past two years for its sponsors. Twice it has broken loose from its moorings, and has been out of action for several weeks at a time.

Dr. Hugh J. McLellan, Jr., Associate Professor of Oceanography and Meteorology, at Texas A. & M., says that sufficient information was obtained from the buoy to indicate that this type of fixed transmitting station, far out at sea, will greatly improve forecasting methods. An attempt is being made to interest several organizations in the possibility of establishing a network of eight to ten fixed weather buoys across the Gulf.

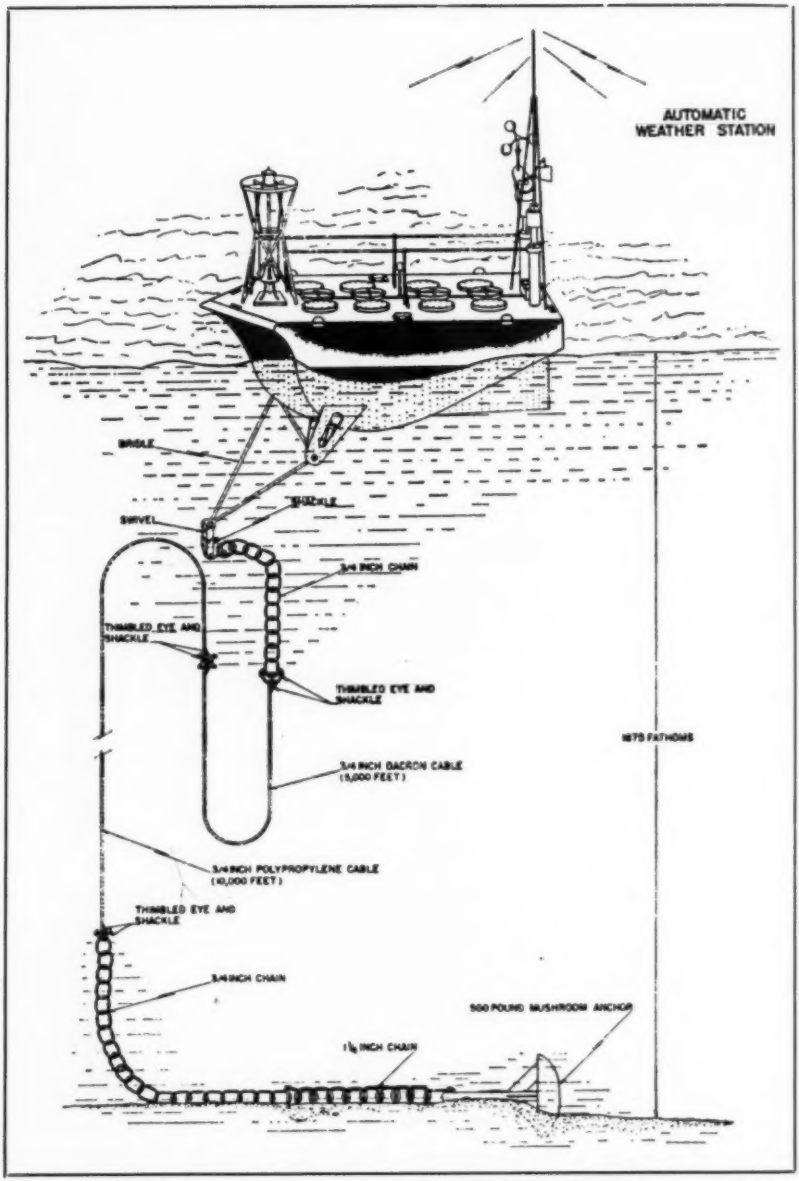
At present, the only advance information on Gulf weather, received from any distance offshore, comes from those merchant ships that transmit regular observations en route, under various contracts with the Weather Bureau—or from the Coast Guard units operating in the Bay of Campeche area, near the Yucatan Peninsula and the Mexico-Honduras coast.

This leaves a tremendous uncovered area of the Gulf, particularly in the southwest, where very little weather information is available. In addition, unless a ship happens to be in a weather build-up area at just the right time, there is no possibility of obtaining this information.

Cradle of Texas Weather

The Gulf of Mexico is not only the cradle of Texas weather, but also furnishes the impetus for most of the major changes in the Great Plains, and is significantly important in the build-up of many seasonal storms in the northeast. At least one-third of all the hurricanes that strike the United States are spawned in the Gulf of Mexico.

Development of long range weather forecasting facilities in the center of



THE PROBLEM OF ANCHORAGE *was solved by The Woods Hole Oceanographic Institute. The above diagram shows the mooring system used to anchor the weather station. To date, the system has withstood all stresses and strains.*

the Gulf is of immediate, and apparent importance to the Texas petroleum producers and sulphur companies using offshore rigs. More advance information on all weather fronts originating in the Gulf is also vital to the weather bureau and to the general public.

The boat-type buoy, as at present designed, is 20 feet long and 10 feet wide. Two masts, a large flashing beacon, a bell, and a railing form the superstructure. Meteorological and electronic equipment and batteries are in water-tight wells extending below the deck.

A buoy similar to this in 1959 was anchored on a sea mount between New Zealand and the Antarctic, and provided weather lore from there. Broadcasts, which last four minutes, first identify the sending buoy and then, in three-letter coded groups, report the weather information. The signals can be received on standard receivers, and decoded according to a prepared table.

The signals can be picked up 800 miles away by day, 1,000 miles away by night.

Unique Mooring System

"The Woods Hole Oceanographic Institute," *The Marine Observer,* a British government publication, recently reported, "solved the anchorage problem by developing a suitable mooring system. The mooring system consists principally of a ¾-inch polypropylene semi-buoyant cable 10,000 feet long."

The yoke is directly attached to the hull, through swivels and shackles. Then comes 100 feet of ¾-inch chain, 6,000 feet of ¾-inch dacron, then the polypropylene, and finally 255 feet of ¾-inch chain and a 500-pound mushroom anchor. "To date," says *The Marine Observer,* "the anchorage has withstood all required strains and stresses."

Drifting Buoy, Another Type

Another type of unmanned weather station, tried by the Bureau of Standards, is a drifting buoy. This kind requires that you locate it first by getting a radio triangulation fix, and has not proved as satisfactory as the boat-type.

As a weather station, the boat-type buoy may have more uses in the future than Texas Towers, such as the one that toppled into the sea off New Jersey, January 15, 1961, with a loss of twenty-eight lives. That Texas Tower was, of course, primarily a radar station.

Hazardous jobs for men at sea or near the sea are being reduced. Already, at many places, unmanned lighthouses run by diesel engines have replaced those operated by lighthouse-keepers. For the sea to become dotted with automatic weather-transmitting buoys would seem to be a logical next step.

The Incredible Sea Horse

By M. D. BELLOMY

EDITOR'S NOTE: For some time members of the Foundation and other readers of *Sea Frontiers* have asked for an article on the sea horse, describing its habits, food, and how it might be kept in a home aquarium. The accompanying article, by a science writer who has actually raised sea horses in her home, should answer many of these questions.

IN THE SEA HORSE, parts of several animals seem to be combined in an incredible creature that brings squeals of delight from children and exclamations of wonder, or rank disbelief, from adults.

The sea horse has, in miniature, a head like a horse, a body like an insect, a tail like a monkey, eyes like a chameleon, a brood pouch like a kangaroo, and armor like one of King Arthur's knights. The armor is composed of interlocking bony plates, comparable to fish scales, only more heavily developed. In addition to this outer shell, of course, there is also the internal skeleton found in all fishes.

Many Ringed Body

The plating looks as taut as the head of a drum and has a lacquerish sheen, which tends to give the sea horse's body a peculiarly insect-like appearance.

Ridged rings made of tiny skin-covered knobs and spines are formed where the plates join together. The rings are responsible for the irregular polyhedron shape characteristic of all members of the family of sea horses. From neck to tail-tip, diminishing in size and situated closer and closer together, more than fifty such rings appear on some adult horses.

The mouth of the sea horse is a round hollow tube, which opens and closes with a rapid trap-like movement producing a distinct smacking sound which can be heard, if one listens attentively, when the fish snaps at food. Sea horses also make a noise during the spawning season by clicking their jaws rapidly up and down.

No teeth, no ribs, no stomach has the sea horse, and he usually swims in a near-vertical position except when sick or giving birth.

Rachel Carson says, "So effective is the camouflage of one inhabitant of the grass—the sea horse—that only the sharpest eye can detect one at rest, its flexible tail gripping a blade of grass and its bony little body leaning out into the currents like a piece of vegetation." Even when they are captured by seining, their mottled coloring blends so deceptively with the netting and the netted plant stems and grass blades that it is far easier to overlook than to see them.

PAPA SEA HORSE GIVES BIRTH *to a young sea horse! Other newborn sea horses can be seen swimming about. In an amazing switch in roles, the female deposits her eggs in the male sea horse's brood pouch, which is like a super incubator. The male then acts as both mother and father, nurturing the brood until birth, some forty-five to fifty days later. (Marine Studios, Marineland, Fla.)*

The most animated part of the sea horse is his eyes; each can move independently. A sea horse may be appraising the world outside his glass aquarium wall with the right eye, while he scans the bottom of the tank with the left.

A deliberate mode of behavior gives these odd little animals a dignity out of keeping with their comic appearance. No sea horse ever moves rapidly. Each movement is slow and precise. One collector of sea horses surmised that if no fish moved any faster than the sea horse, no method of capture except nets ever would have been invented.

For locomotion the sea horse depends upon the movement of small fins, one dorsal and two pectorals. These fins are almost transparent, so that the sea's little horses often appear to trundle through the water by no visible means. Although such fins look fragile and lacking in strength, they are little dynamos. The slow-motion camera shows that each part of each fin may vibrate back and forth as fast as 35 times per second, very rapid for movement in water.

"Horse-Caterpillar"

The sea horse's generic name *Hippocampus* means "horse-caterpillar." This alludes not only to the horse-like head but also to the caterpillar-like tail. When straightened out, the sea horse's tail does resemble a caterpillar, but in practical use it is far more monkey-like. With it the sea horse is able to grasp and hang onto pieces of rock, coral heads, grass blades, plant stems, gorgonians, and other objects, and to hold itself stationary even in swift currents and tides.

With great patience and considerable effort aquarists have persuaded certain species of sea horses to eat nonliving food. In a majority of cases until less than two years ago, however, they would starve to death surrounded by food, if that food did not move. During the latter part of 1958 a nonliving frozen food designed especially for sea horses was devised. This food is in limited production and the demand far exceeds the supply. But if production is increased, most aquarium sea horse feeding problems will be solved.

Shrimp Favored as Food

In general, sea horse diet depends upon the species. The natural food of the larger species consists of sea shrimp, not more than half an inch long, and a variety of aquatic insects. If the aquarist, attempting to maintain large sea horses, lives fairly close to the sea, canals, or lakes and streams, it is possible to collect natural food.

In the ocean, small shrimp may be obtained by dragging a net or small seine through grass flats or by collecting seaweed and shaking it vigorously in a pail of sea water. A few days' supply of such food may be kept in the home if ample aeration is supplied, and fine dry food is placed in the container for the prospective food shrimp to eat.

Smaller varieties of fresh or brackish water shrimp, collected with dip nets, will be equally relished by large

MASTERS OF CAMOUFLAGE. *How many sea horses can you find in this photograph of a family living among the rocks and sea anemones in a tank? The editors believe there are at least eight. (Photograph by author)*

EXHAUSTED FATHER CONTEMPLATES *his brood. It seems hardly possible that the male's now collapsed pouch could contain the 150-200 tiny replicas shown to the right. But papa sea horse soon regains his natural "figure"; the slot at the top of the pouch closes and internal tissue returns to normal. (Marine Studios, Marineland, Florida)*

sea horses. In rare instances, all except dwarf sea horses can be trained to eat adult frozen brine shrimp if it is thawed and set adrift in the tank to simulate a slow swimming movement.

Males Busy Having Babies!

The feeding of dwarf sea horses, even the newborns whose mouths are no larger than the dot over an "i", presents few problems. A separate tank or container can be kept constantly "set" with brine shrimp and if enough of these tiny crustacea are maintained in the sea horse tank, the dwarfs will be well-fed and probably will mate and produce young ones.

In sea horse circles, few eligible bachelors will be found in the late spring and summer months. Most adult males are busy having babies then. Contrary to some reports, both male and female indulge in wooing and courting. First, the two lock tails, like humans holding hands and swinging down the lane. Then one of the pair begins to quiver rapidly and rhythmically. Abruptly, the performer becomes motionless. This halt seems to be the signal for the partner to commence the same gyrations. The off-and-on dance continues sometimes twenty to thirty minutes ending finally in an embrace. The female inserts a special organ, used for transferring the eggs, into the male's brood

pouch, which is at the end of his body right above the tail.

Sea horse eggs are beautifully colored. The nucleus is slightly deeper than salmon pink and it is protected by liquid in a sack-like transparent membrane. The male sea horse's brood pouch, a super incubator, has a small slot-like opening in the middle near the top which is sealed tight as soon as the last egg is received.

Both Mother and Father

Then the male acts as both mother and father, supplying oxygen and food, disposing of waste products and intimately nurturing the brood until birth. In most species, the youngsters start coming out of the pouch after forty-five to fifty days of incubation.

The infants stir about inside the pouch as soon as the eggs hatch and the father sea horse seems to have a period of labor. The distended pouch seems to grow larger and larger and the sea horse moves slowly back and forth across the aquarium like a human father pacing a hospital corridor.

The slow movement stops, sometimes after only an hour, but more often after two to several hours, and a period of twisting and writhing begins. All the while vigorous muscular contractions of the pouch occur regularly. Not infrequently a pallor creeps over the sea horse's entire body.

150-200 Tiny Replicas

Among the larger species delivery results in the birth of 150-200 tiny replicas of the parent fish, each about a quarter inch long. There are sev-

WITH ITS MONKEY-LIKE TAIL *the sea horse can grasp and hang on to plant stems, rocks, grass, and other objects, holding itself stationary even in swift current and tides. Young sea horses tail-hook anything they can, usually the tail of one of their brothers or sisters, or some part of their parents' anatomy. This is the Sydney (New South Wales) sea horse, photographed at the Sydney Zoological Gardens. (Australian News and Information Bureau)*

eral expulsions, the entire process often extending over two, three, sometimes four or more, days. As many as twenty-five to thirty or as few as ten to fifteen babies may be spewed forth at each expulsion. When all but the last stubborn few have been delivered, the male presses his pouch hard against rocks, shells, or any handy solid object to dislodge the final remnants of his new broods.

After the birth is complete the muscular contractions of the pouch continue for varying periods, gradually growing less violent, until finally, deflation to normal form is achieved. The slot at the top of the pouch closes and internal tissue returns to normal.

As soon as the babies are born, they rise to the surface of the water and tail-hook anything they can, usually the tail of one of their brothers or sisters or some part of their parents' anatomy. They often pull in opposite directions, just as adults do, thus exercising their minute muscles as they begin a constant search for food.

Approximately fifty different species of sea horses are known. All are

SEA HORSES GET SICK TOO. *While they adapt readily to aquarium life, the little creatures need occasional medical attention. Here Elizabeth Goetz, of Marine Realm, treats a sea horse for white-spot fungus, while its brothers and sisters seem to be watching anxiously from the aquarium in the background. (Photo by author)*

found primarily in warm seas. A few representatives, however, also inhabit comparatively cold waters. The largest, *Hippocampus ingens* (Girard), known as the Pacific sea horse, is found from the extreme southern part of California to Northern Peru. This sea horse is truly a giant. It is not unusual for an adult to grow a foot long.

Varieties best known along the eastern seaboard are *Hippocampus erectus* (Perry) and *Hippocampus zosterae* (Jordan and Gilbert). The former is commonly known as the giant, and the latter, as the dwarf sea horse.

Found in Hudson River

H. erectus was known for a long time as *H. hudsonius. H. erectus,* according to some, consists of two subspecies. The northern form occurs from South Carolina to Cape Cod during the summer months. Where it goes in the winter is still a mystery. The specific name *hudsonius* was given this species because it frequently enters, settles down and raises a family in the Hudson River, as far upstream as the water remains brackish. Coloration ranges from light to dark gray although occasionally specimens of brilliant yellow and some of jet black are collected. When mature the northern form usually averages about eight inches in length, although both smaller and larger adults are not uncommon.

The Southern Giant

The southern form, once called *punctulatus,* is known as the southern giant in some areas and as the Bermuda sea horse in other places. This subspecies inhabits coastal, weed-covered sea bottoms from North Carolina to the Tortugas and is frequently found clinging to Sargassum and other floating seaweeds. Adult length of this giant is seldom more than five or six inches. Coloration often approximates that of the colder-water relative except that russet red, brilliant yellow and pearly white specimens are sometimes found and, rarely, a startling green individual is hauled up, usually in commercial shrimp nets.

General confusion has prevailed through the years as to proper classification of *H. erectus.* Individuals collected in sargassum or other floating seaweed tend to have fleshy tabs or decorations growing all over the body. Animals that are removed from this environment lose such appendages after a period of time, whereas others without such ornamentation will grow a rather bewildering array of protuberances when placed in a seaweed or sargassum environment and left there for several weeks.

Easy to Keep at Home

Adult dwarf sea horses never grow longer than two inches. They are found most abundantly in the grassy shallows of South Florida, both on the Gulf and ocean sides. Dwarf sea horses are often fawn color; however, the color may deepen to dark brown or it may fade to an oyster or off-white.

Sea horses, especially dwarfs, are comparatively easy to keep in the home aquarium. The prospective sea

horse collector needs only to follow a few simple rules.

Sea horses may be kept in natural sea or artificial salt water with a salinity reading of not less than 10.020, preferably 10.025. If large specimens are to be maintained, at least a ten-gallon aquarium should be used. A sub-sand or bottom filter is recommended, but corner filters containing about a half-inch of charcoal topped with a packing of glass wool, will suffice. *Properly cured* rocks, long shells, staghorn coral, sea fans, calcareous algae and skeletons of gorgonians should be placed in the aquarium, not alone for decorative purposes, but as hitching posts to which the seahorses may anchor themselves.

Enough aeration should be provided so that the aquarium water ripples. Sea horses are accustomed to moving water and seem to adapt to captive life better in circulating water. Depending upon the species to be maintained, it is necessary to keep an adequate supply of food in the tank continually. Sea horses prefer to eat most of the time.

Sea Floor Maps Benefit Tuna Fisheries

For ten years scientists have been mapping the Pacific sea floor from southern California to northern Chile, and for several hundred miles seaward. Millions of echo soundings disclosed seamounts and drowned canyons, as well as other ups and downs of Neptune's realm.

Since these maps have been made available to commercial fishing interests by the U. S. Bureau of Commercial Fisheries Biological Laboratory, San Diego, and the University of California's Institute of Marine Resources, the tuna industry in particular has benefited.

"Frequently tuna are found in greater abundance around seamounts and deeper protuberances rising above the sea floor than in surrounding waters," according to Gerald V. Howard, Director of the Biological Laboratory. "The accidental discovery of Shimada Bank, off the west coast of Mexico, and the ensuing large catches of yellowfin tuna, were largely instrumental for the initiation of the project to analyze and plot the large amount of sounding data collected during the past decade by research vessels of Scripps Institution of Oceanography and other agencies," he adds.

A series of twenty-four charts covering the area from 35 degrees North latitude to 24 degrees South, and 600 to 700 miles offshore will eventually be printed and issued. They are available free to interested parties from the Biological Laboratory, Box 6121, Point Loma Station, San Diego 6, California.

LIKE A GREAT GRAY GHOST *a large nurse shark glides past the photographer. This close-up, taken in captivity, shows how well streamlined is the shark's long body. (Miami Seaquarium)*

Let a Sleeping Shark Lie

By JOHN E. RANDALL
The Marine Laboratory, University of Miami

THE NURSE SHARK of Florida and the West Indies is encountered by skin divers more frequently than any other kind of shark. It is popularly believed to be completely harmless. Until recently this view was held also by ichthyologists who specialize in the study of sharks.

Bigelow and Schroeder wrote in *Fishes of the Western North Atlantic* (1948), in reference to the nurse shark, "This shark is perfectly harmless to bathers . . ." As long as the swimmer does nothing to provoke the shark, this statement may be true. If the nurse shark is grabbed by the tail, or speared, however, it is very capable of putting its tormentor in the hospital.

Tempting Target

The nurse shark likes to lie quietly on the bottom, usually in a cave or beneath a ledge. As such it is a very

tempting target for the spearfisherman. And more than one brazen skin diver has seized a nurse shark by the tail to try to capture it, if small, or get a free underwater ride if it is large. As the following demonstrate, such sport should be regarded as highly hazardous.

On April 4, 1958, Johnny Bowers grabbed the tail of a 5-foot nurse shark off Miami Beach to get an underwater tow. The shark bit him on the right thigh and would not release its hold even when a companion spearfisherman fired a spear through it. Bowers was helped into a boat with the shark still hanging on to his leg, and ten minutes were required to extricate its jaws.

Bites the Hand that Feeds

In 1956, Beryl Charwick was about to feed nurse sharks in a pen at the Cape Haze Marine Laboratory at Placida, Florida, for a demonstration to school children. He ordinarily attracted sharks by tapping the water with his hand prior to giving them the food. As he was doing this, he was distracted by a visitor coming onto the feeding catwalk with him and he looked around. At this moment a nurse shark of 8 to 9 feet in length struck at his hand. even though it was several inches from the surface, and bit off the end of his right index finger.

On June 17, 1958, B. Irving of Miami, Florida, was trying to drag ashore a 3½-foot nurse shark which he had caught by hand off Key Biscayne. The shark removed a piece of his thigh about three inches long.

Accidental Encounter

Eric Cockerill, on June 26 of the same year, was wading in about three feet of water off Sanibel Island, West Florida, when he was bitten on the right foot by a nurse shark estimated to be seven feet long. He evidently walked into the front end of the shark which was resting on the bottom.

About three weeks later, near Sarasota, Florida, in six feet of water, John Hamlin was bitten by a 5-foot nurse shark after grabbing it by the tail.

On July 2, 1959, thirteen-year-old King Scherer was bitten on the arm by a 2½-foot nurse shark in ten feet of water at Delray Beach, Florida, after grasping the shark by the tail. The boy swam 150 yards to shore with the shark.

Puerto Rican Battling

A manuscript by Teas and Erdman lists three encounters with nurse sharks in Puerto Rican waters. In one instance Teas prodded at a 9-foot shark with a hand spear only to have it make two or three passes at his legs before being driven off. On August 12, 1954, near Boqueron, Dr. H. Warmke speared a 58-inch nurse shark which weighed thirty-four pounds. The shark rolled and entangled Warmke in the cable of the spear. Dr. Teas also speared the shark. The shark bit Warmke twice on the right thigh. Then it bit him on the left calf, removing a piece 3 inches long and ½ inch thick.

Teas grabbed the shark by the tail. and it twisted around and bit him on the right knee and held firmly. Initial

DON'T GRAB THAT TAIL! *A skin diver in the Virgin Islands approaches a 4-foot nurse shark. This shark is commonly encountered lying on the bottom, often beneath ledges of rock or coral, and may allow a diver to come close enough to grasp its tail. Such foolhardy behavior, however, can bring disastrous results. Note the rear position of the two dorsal fins, the absence of a lower lobe on the tail fin. Together with the long barbel at the front of the nostril these are distinguishing clues. (Robert E. Schroeder)*

efforts to pry off the jaws failed. Only after the shark was killed with repeated knife thrusts was it possible to force the jaws open.

The third incident took place near Ramey Air Force Base; no date was given. A skin diver picked up a nurse shark estimated to be 18 inches long, by the tail, to show to bystanders. The shark turned and bit him on the arm, holding on so tenaciously that it had to be killed to be removed.

Bitten On Chest

In February, 1958, at Water Island, St. Thomas, Virgin Islands, U.S. Navy U.D.T. diver R. Gerringer attempted to pull an 8-foot nurse shark, into which three spears had been fired. The shark bit him in the pectoral muscle region on the left side of the chest.

In his recent book *Shark Attack*, Coppleson recorded the nurse shark experience of John Fenton, in full dress diving suit in 40 feet of water off Andros, the Bahamas. When a

EVEN LITTLE ONES BITE! *Thirteen-year-old King Scherer displays a 2½-foot nurse shark which ripped his arm after he grabbed for the shark's tail while skin diving 150 yards offshore at Delray Beach, Florida. The boy swam ashore with the shark. (Press Bureau, Delray Beach, Florida)*

7-foot shark came up to him, he patted it on the head. The shark responded to this affectionate gesture by biting him on the sleeve. Unable to unlock the shark's jaws, even with

a knife, Fenton finally freed himself by cutting away his sleeve.

Author's Experiences

Before learning of these incidents, the author tried to catch a nurse shark about 20 inches long in the Virgin Islands by grabbing it by the tail. The shark twisted back with great agility and nearly bit the arm that was holding it.

While the author was skin diving with the late Conrad Limbaugh, at Cat Cay, Bahamas, in June, 1948, the latter encountered three nurse sharks of six to seven feet in length, lying together beneath a ledge. He noted a remora on one of them and approached the shark to try to photograph the remora. This shark and one of the other two came out from beneath the ledge and swam upward after him as he retreated to the surface. The sharks scraped their backs on the edge of the overhanging rock as they arched upward at Limbaugh. They came close to him when at the surface, and he considered their movements aggressive.

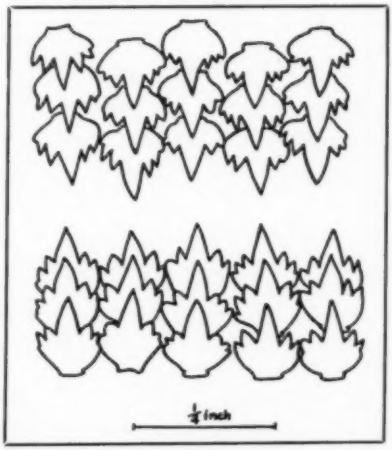
One of the strangest events concerning nurse sharks occurred in Martinique in 1954, and was related to the author by J. Morice, Chief of the Laboratory, Institut Scientifique et Technique des Peches Maritimes, Guadeloupe, French West Indies. With no provocation a 6-foot nurse shark attached itself with its jaws to the top of the chest of Bernard Vieux, and seemed to embrace him with its pectoral fins. Vieux was able to free himself only with great difficulty. When the author tactfully indicated to Morice that the incident seemed a little too bizarre to be believed, he said he had seen the contused area and tooth marks of the nurse shark on Vieux's chest.

No Fatalities—Yet!

Fortunately, none of these victims of nurse shark bites have died. This shark has a small mouth and small teeth, so cannot render as much damage as most species of sharks of comparable size. But the tendency of the nurse shark to hang on with bulldog tenacity after it has bitten could easily cause a man to drown.

The nurse shark is readily distinguished from other Atlantic species of sharks by a long barbel on the margin of each nostril and by a groove which

SMALL BUT EFFICIENT *are the teeth of the nurse shark. They are distinctive in bearing two or three little cusps to each side of the large central cusp. The teeth occur in about eight functional rows in each jaw, each row with about thirty teeth. Fossil teeth prove the nurse shark once swam the Mediterranean. (Drawing by Helen A. Randall)*



connects each nostril to the mouth. The caudal or tail fin has a long upper but no lower lobe. The color is yellowish to grayish brown. Two large dark spots may often be seen on the back near the head. Young individuals may have scattered small black spots. The snout is short, thus the mouth appears almost terminal. The small teeth are very characteristic. They have a high triangular central cusp, flanked on each side by one to three small cusps.

The teeth of nurse sharks have been found in fossil deposits in the West Indies and Europe from the Upper Cretaceous period, indicating that these sharks swam in warm seas over seventy million years ago.

None In European Waters

Today, the nurse shark does not occur in European waters, probably because of the cooler sea temperatures. Its present range shows fondness for warm water—tropical West Africa and on the American side of the Atlantic, from southern Brazil to North Carolina. It is quite common throughout the West Indies. A year-round resident on the western coast of Florida north to Tampa, the nurse shark extends its range to the northern Gulf of Mexico during the summer.

What does the nurse shark eat? Primarily invertebrates, such as crabs, spiny lobsters and sea urchins, but it is known to take fish as well. It is considered a scourge by fishermen in the Lesser Antilles because it attacks fish traps (often made of plant materials) and devours the fishes in them. Its heavy feeding on crabs and lobsters makes it an undesirable species from an economic standpoint.

Hide and Liver Once Valuable

At one time the nurse shark had some compensating attributes. Its hide was especially valuable, having the best quality of all American sharks, and oil from its liver was utilized for production of vitamin A, although the yield was relatively low. Shark fishing, in general, is no longer commercially feasible, because it is now cheaper to synthesize vitamin A; other abrasives have tended to replace shagreen for polishing wood; and the market for sharkskin is limited (see also "Sharks are Useful," *Sea Frontiers,* Vol. 4, No. 4).

The nurse shark attains a larger size than most persons would realize. They are reported up to 14 feet in length. They mature at a relatively small size, however. A 5-foot female containing well developed embryos has been reported. Nurse sharks have been observed mating in shallow water. The male grasps the female with his mouth at the edge of her pectoral fin. As a result, these fins in females may be scarred.

The nurse shark is ovoviviparous, which is a tongue-twisting way of saying that eggs are formed within the body and pass into the oviduct where part of the development takes place. The embryos break out of the curious horny blackish shell of the eggs and complete their development in the uterus.

Why Sharks Keep Mouth Agape

Very few sharks are able to lie motionless on the bottom, and prob-

ably none rest in this manner as often as the nurse shark. Most sharks must keep swimming constantly in order to respire, and for this reason the mouth is held slightly open. Upon seeing a shark with mouth agape, a skin diver might interpret this pose as preliminary to an attack which, of course, need not be the case.

The sharks which must keep moving to respire are difficult to capture alive and usually very hard to maintain in an aquarium or oceanarium. The nurse shark, however, adapts very well to captivity. It is somewhat spine-chilling to see it attack an offering of dead fish at meal time with the same savage fury that is exhibited by other more feared species, such as the lemon shark and bull shark.

The Atlantic nurse shark has two near relatives in the Pacific and Indian Oceans. But it should not be confused with a species called the grey nurse shark in Australia. This sinister beast is one of the most feared sharks in Australia and South Africa, where is it believed responsible for most shallow-water attacks on bathers. We are fortunate, indeed, in not having this shark in American waters. A close relative, the very common sand shark or sand tiger of the eastern seaboard of the United States, has never been recorded as having attacked man.

Novel Use For Sea Water

From Norway comes a report of a new and unusual use for sea water, as a purifying agent. Sewage has become a serious problem in the narrow fjords of this Scandinavian country. Conventional biological treatments of raw sewage do not solve the problem, because such treatments do not remove the fertilizing elements (phosphorus and nitrogen compounds). For this reason the treated water still causes discoloration and smell in the fjords due to increase of algal growth. Yet removal of even one of these compounds is sufficient to control the growth of harmful algae.

In an ingenious new method, invented by Dr. Ernest Foyn, who has been in charge of chemical investigations of Oslo-fjord, sewage is mixed with 10 to 15 per cent of sea water and subjected to electrolysis. Phosphorous compounds in the sewage are precipitated as magnesium and calcium salts, which together with sludge and suspended particles, adhere to magnesium hydroxide at the cathode.

Phosphates and sludge are in turn floated to the surface as a scum by means of hydrogen gas liberated during the electrolysis, and scraped off. Chlorine developed at the anode is used for disinfection at the outlet. A plant of this kind, installed by the authorities of Oslo, now treats sewage from about 1,200 people, and seems to confirm the promising results of pilot plant tests.

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Soviet Institute Beyond the Artic Circle

By L. CHERNUSKO

EDITOR'S NOTE. The editorial staff of *Sea Frontiers* has had many inquiries as to the status of Soviet research in oceanography and how the United States stands in comparison. In an effort to inform our readers in this important area, *Sea Frontiers* published an article "Marine Science, Soviet Style, May 1959, Volume 5, Number 2, by the American scientist, Harris B. Stewart, Jr. Here is an unsolicited article submitted by a member of the staff of the Washington Embassy of the U.S.S.R. It is printed as originally received. Other articles on related subjects and from various sources will appear in the future.

FOR MORE THAN thirty years now the Arctic Research and Design Institute of Sea Fishing and Oceanography has been functioning in Murmansk, U.S.S.R.

The Institute carries on a broad program of comprehensive sea research as part of its assistance to the Soviet fishing fleet which operates in the vast expanses of the Atlantic. The principal fish caught in the new fishing grounds is bass. Inasmuch as it is essential to know the age of the fish, stock formation, etc. it is here that the Institute is very helpful. And similarly in relation to herring, which also figures on the Institute's research program. As a result, the Institute's scientists spend six to eight month at sea every year.

200 Bathysphere Dives

Much information important to oceanography and fishing has been acquired by Oleg Kiselev and Ivan Lagunov, both of them Masters of Science, and their co-workers of the GKS-6 bathysphere. In all, the team has made more than 200 dives to various depths.

"An unusual and almost fantastic world appears before the explorer at a great depth," says Oleg Kiselev, who heads the laboratory of new fish-prospecting methods. "Looking through the portholes, we can watch many of the sea's inhabitants and learn much about their life and habits."

As though to give more weight to his words, the young scientist invites us to the Institute's museum where amazing and often unique exhibits are on display, collected from under the ocean's waves. Apart from all types of plankton, nekton and benthos—the three groups of sea fauna of special interest to fishermen and scientists—they include exotic sea gifts. Here is the angler fish. Its fishing rod is a fin as long as a thin cane with a phosphorescent blob at the end. The gleaming bait attracts small fry into the angler's mouth.

Our attention is immediately attracted by the electric ray — a fish with natural storage batteries which

EXPLORING THE *southernmost continent. One of the ships of the first Soviet Antarctic expedition noses into a rocky inlet near Mirny. (A. Kochetov)*

NUCLEAR-POWERED ICEBREAKER. *Residents of Leningrad, U.S.S.R., throng the Neva riverside to see the* Lenin, *first vessel of its kind. With a displacement of 16,000 tons, and 440 feet long, the* Lenin's *atomic boilers develop enough steam to produce 44,000 horsepower and move her at a speed of 18 knots in clear water. (D. Kozlov)*

store much electricity. The shock produced by a ray is similar to what an electric current of 300 volts and 7 or 8 amperes would do to man. The fish was caught by a Soviet ship off the west coast of Africa. No less amazing are the luminescent anchovies. Their light is intensified by what may be called lenses resembling eye lenses and by peculiar silvery reflectors. The body of the fish is spangled, as it were, with tiny searchlights.

In another laboratory we are shown a bathysphere. Explaining the apparatus, Kiselev remarks: "With its help we have found out that the echo sounder does not affect the behavior of fish. The prejudice of some skippers is thus proved groundless."

The bathysphere has helped the scientists to learn how game fish travel in the sea and how light and fishing gear affect them. Soon the Institute's staff will resume their studies in a new bathysphere. Capable of diving as deep as 600 meters or more, it will give an insight into the life of deepwater fish, notably bass which accounts for a lion's share in the catch.

Much has been learned about fish in the five research voyages of the submarine *Severyanka* to the North Atlantic and the Barents Sea. Among other things, the scientists saw the Institute-designed variable depth trawl at work.

"By far the greatest help, however, comes from surface research ships," says Vitold Maevsky, director of the Institute. "They are equipped with the latest instruments useful in a wide range of investigations at sea. Some of the ships have already made more than a hundred voyages, often in stormy weather."

The ships *Professor Mesyatsev* and *Academik Berg* surveyed vast areas in the North Atlantic. What they have learned there is a good basis for herring fishing to develop on a large scale, using up-to-date techniques.

100,000 Tags as Migration Clues

Another project of the Institute is fish tagging. In all, more than 100,000 fish have been tagged by the Institute's staff. In this way reliable charts can be compiled of the migration of cod, haddock and bass.

The Institute maintains broad scientific contacts with foreign scientists. It has played host to delegations from Poland, Czechoslovakia, Norway,

CONTROL CENTER. *Deep within the U.S.S.R.'s atomic-powered icebreaker* Lenin *is this power plant and buoyancy control post. Launched in 1957 and commissioned two years later, the* Lenin *escorted ships through the Arctic ice in 1960. (D. Kozlov)*

East Germany, North Korea, China and North Vietnam. The foreign scientists obtained first-hand information about fish research, fishing practices, prospecting and fish processing in the Soviet Union. Incidentally, a group of Polish scientists from the Sea Fishing Institute in Gdynia came to Murmansk aboard their research ship *Bircut*. The Soviet scientists paid a return visit to their counterparts in Gdynia.

Many Research Ships in Area

Just as close are the contacts with Norwegian scientists. Being neighbors, they carry on their researches in the same areas. Mention should also be made of contacts with Iceland and Canada. The Institute's research ship *Persei II* recently made an oceanographic research voyage in the vast area between the Faeroes and Iceland where large-scale fishing operations are going on. Also sailing there are the research ships of Norway, Britain, Scotland and West Germany. Like the Soviet Union, those countries are members of the International Council for the Exploration of the Sea.

The Institute exchanges publications with its counterparts in Norway, Iceland, Britain, Denmark, East Germany, Poland, West Germany, Canada, the United States, etc.

Because it is helpful to both sides, every encouragement is given to contacts between Soviet and foreign scientists.

EMBLEM OF THE CRUSADERS. *The lion's paw,* Pecten nodosa, *was worn by pilgrims who had been to the Holy Lands. Related to the scallops, this robust shell swims by jet propulsion, and is much sought after by shell collectors. Note the reinforcement to the shell offered by ridges and knobs. (Gilbert L. Voss)*

Jonah And The Whale

A NUMBER of queries have followed the publication, in the June, 1958, issue of *Sea Secrets,* of a question concerning a man swallowed by a whale and emerging alive after three hours. At the time the editors could not cite any reference to substatiate the report. Since then a letter has been received from Captain Eugene A. Coffin, Jr., U. S. Coast Guard, of Seattle, directing attention to an article in the May, 1958, *Skipper* magazine. Under the title "Jonah and the Whale," David Gunston writes of the experiences of James Bartley, a seaman in the *Star of the East,* who was swallowed by a sperm whale in February, 1891, and lived to tell the tale after some hours in the huge creature's stomach.

Seashells . . . Half Billion Years Evolving

By GILBERT L. VOSS

ON MAY 6, 1952, the Danish research vessel *Galathea* lay on station in the Pacific at 9° 23′ north latitude, 89° 23′ west longitude off Costa Rica. To the whine of the deep sea winch, the trawl which had been sweeping the ocean bottom at a depth of over 10,000 feet was raised dripping from the sea and deposited on the rolling deck.

LIVING FOSSIL. *This limpet-like mollusk was believed to have died out among earth's creatures 350,000,000 years ago. Then, ten healthy specimens were dredged up by the Danish research vessel* Galathea *in 1952. It was named* Neopilina galatheae. *(Smithsonian Institution)*

There is always excitement and interest among biologists when a deep haul comes aboard, for who knows what new and exotic creatures the sea will give up for the first time to the eye of man? On this occasion, scientists peering into the mud and debris saw a small, insignificant looking limpet-like mollusk. Limpets of course are not unusual, but they certainly should not be living 10,000 feet down in the sea! This was something different! A careful search was made and before the *Galathea* moved on to new adventures ten living specimens and three empty shells of a type never before found had been collected.

Living Fossils

The carefully preserved specimens were turned over to Dr. Henning Lemche and his colleague, K. G. Wingstrand, at the University of Copenhagen. With growing wonder they examined the material and then realized that here, in their very hands, were specimens of a group of mollusks, the Monoplacophora, which supposedly had died out from among the earth's living creatures about 350,000,000 years ago! Lemche named his new mollusk *Neopilina galatheae* for the vessel which captured it.

Shortly afterwards, ten more specimens of a new species closely related to the first were found by the Lamont Geological Observatory's vessel *Vema* from over 19,000 feet down, in December, 1958, off the coast of Peru. Clarke and Menzies named this new form *Neopilina* (*Vema*) *ewingi*. Truly the sea was giving up a real secret.

Detective Feat

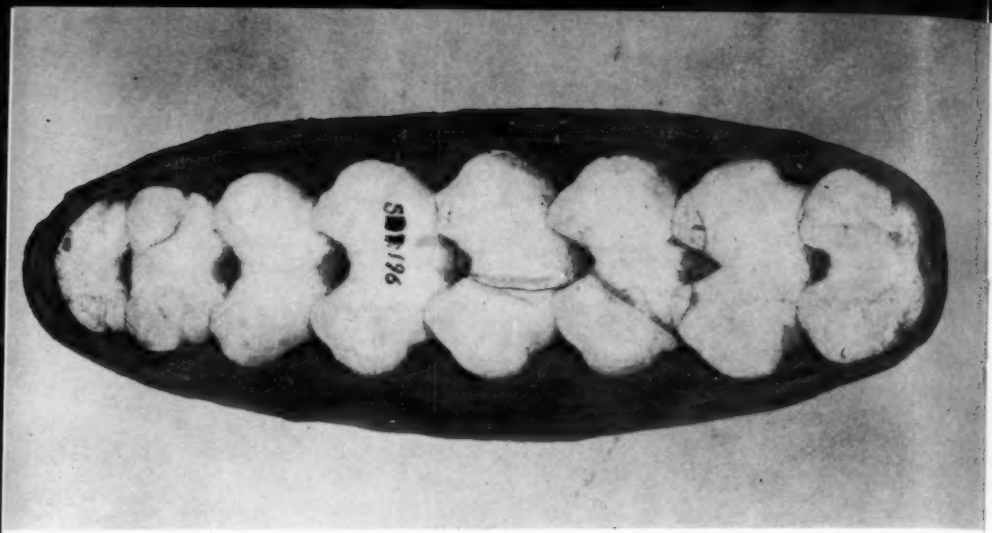
Monoplacophorans are known as fossil shells from the very old geographical strata (Early Cambrian to at least Middle Devonian), and some paleontologists had long considered that they might be the forerunners of our modern mollusks.

One of the great detective feats of modern zoology was accomplished by Brooks Knight when he described, in 1952, this animal as it might have been when alive. His description was deduced from the muscle scars on the empty shells and his knowledge of molluscan anatomy. Few were surprised that the animal dredged up by the *Galathea* resembled this so closely that Brooks Knight might have used it for a living model.

PROPER IDENTIFICATION *is a necessary part of all biological investigations. Here a student works on the classification of marine shells at the Institute of Marine Science, University of Miami, which has extensive study collections of tropical and sub tropical shells of the world. (Walter R. Courtenay, Jr.)*

Worm-Like Ancestor?

Of course, the discovery of *Neopilina* renewed old interest in the family tree of the mollusks. Investigations so far carried out suggest that, because of the segmented structure of its body, this interesting species, evolved from a worm-like (Annelid) ancestor. In turn, a *Neopilina*-like mollusk may be ancestor to the snails, clams, tooth shells, and octopus and squid.



COAT OF MAIL SHELL. *More formally known as the giant chiton* (Cryptochiton stelleri *Middendorff). The shell is reduced to eight overlapping plates, held in place by a hard gristly girdle, giving it considerable mobility. It commonly clings to rocks near the shore, crawling about after dark to browse on sea weeds. (Walter R. Courtenay, Jr.)*

Much of the early history will never be known because our only evidence is obtained from shell fossils, but specialists, by studying these shells, are able, like Brooks Knight, to reconstruct not only the shell but often its inhabitant and tell us more about their early development. This of course, raises the immediate questions, what are shells, how are they formed, and how have they become so diverse in form and color?

Infinite Variety

In size, shells range from tiny *Omalogyra* less than ⅛ inch in diameter to the giant clam, *Tridacna,* over two feet long. They vary from sharp spikes to nearly round balls, and from smooth surfaces to masses of long curved needle sharp spines.

In color they vary from deep red, rose and coral to brilliant multi-colored bands to dull white or inconspicuous brown. No wonder they have captured the interest of people throughout our human history. Actually, however, despite all the apparent diversity of form, mollusk shells are formed around one basic type, a single cone.

What Are Shells Built of?

What are they built of, these fascinating structures? Essentially they are made of lime or calcium carbonate. Calcium and carbon are obtained from the sea water and from their food and by a complex biochemical action changed into lime and deposited in the various patterns by the fleshy mantle of the living animal. Shell may be formed in several ways, according to the nature of the particular kind of animal. If cut in cross section, it often exhibits one or more distinct layers from the outer surface inward, due to the varying fashion in which the line crystals are formed.

In a typical mollusk these would consist of an outer prismatic and an inner pearly layer of numerous thin layers of lime and often having a beautiful iridescence. In most mollusks the outer surface is protected by a horny covering, which protects the shell from erosion by carbonic acid in the water.

How did mollusks develop the many different kinds of shells they exhibit today? It is generally assumed, partly by the evidence of *Neopilina,* that the mollusks are descended from a worm-like ancestor (an Annelid.) These primitive mollusks probably had no shell at first, and if seen today would most likely be classed among the worms. At first the shell was represented probably by tiny spicules of lime embedded in the outer skin. Eventually these spicules fused to form a primitive shell which looked much like the simple limey cap of *Neopilina.*

Three Major Shell Types

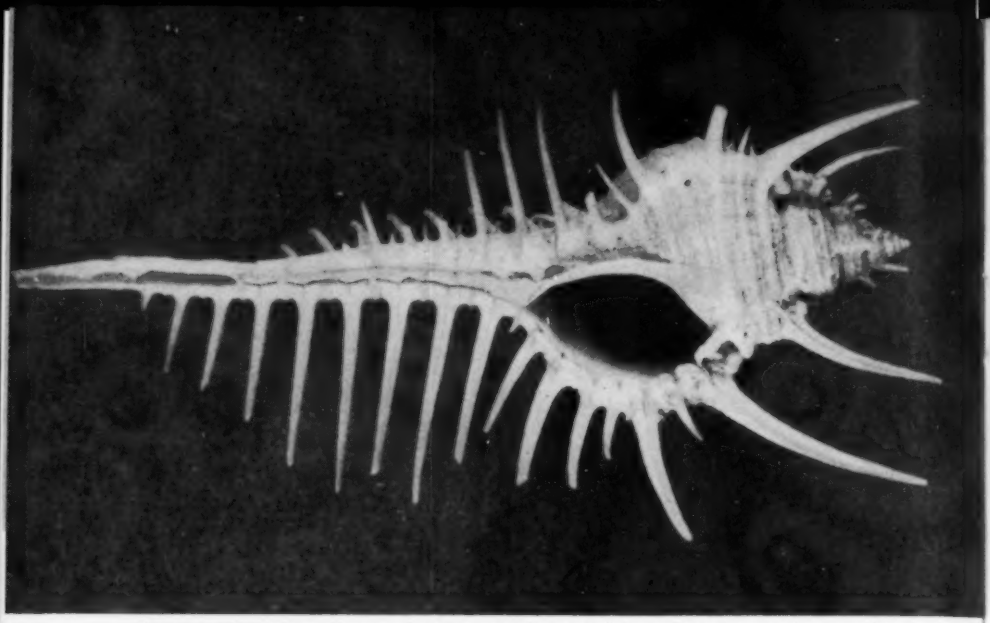
Probably from this simple saucer-like shell four of the five great major groups of mollusks arose, the snails, toothshells, clams and octopus and squid. Basically however these five may be reduced to three major types.

Another type, the curbs, or chitons, is represented by a series of usually eight broad overlapping shelly plates, held in position by a gristly girdle around the edge. This type according to some, may have been derived from the simple cap by cross-wise division of the shell for greater mobility. Others believe it arose earlier by fusion of the primitive spicules. Oddly enough, this type of shell has scarcely changed over the millions of years since it first appeared. This, perhaps, indicates that there is little possible variation permitted by this flexible covering.

Tubes and Bivalves

The second general type of shell is a tube formed by an extension or drawing out of the simple cap. It is seen today in three types, the closely coiled tubular shell of the gastropods or snails with its many variations, the slightly curved simple open tube of the Scaphopods, or toothshells, often highly sculptured, and the flat coiled chambered tube of the ancient ceph-

HARP SHELL *is prized for beautiful colors and graceful design. Though its shell is thin, it is strengthened by ridges or fluting. Indo-Pacific waters abound in harps, but only one species has reached the west coast of the Americas. (Walter R. Courtenay, Jr.)*



LONG SHARP BATTERIES OF SPINES *are often used for protection against predators, such as fish. This bristly shell* (Murex tenuispina *Lamarck) is from the Indo-Pacific. (Walter R. Courtenay, Jr.)*

alopods or octopus and squids. The latter exists today nearly in its original form in the Chambered Nautilus but is reduced to a thin papery internal shell in the squids.

The final type is the simple bivalve skeleton of the clam typical of the class Lamellibranchia. This kind of shell probably came into being when the animal's outer cover or mantle developed two lobes which enclosed a chamber for pumping and straining water. Each lobe then formed a single shelly plate. These became hinged at the back. Even some shrimp-like animals have developed two valves like clams.

Before looking at the infinite variety of forms in the snails and clams let us consider for a moment the way in which these variations could have taken place.

Armor Plating for Protection

Without some kind of protection, most mollusks would quickly fall prey to other animals. The shell is an armor plating that protects the soft flesh from such creatures as crabs, large fish and lobsters simply by its hardness and strength. The strength of their shells may be greatly increased by ridges or buttresses as in the colorful Harp shells. Additional protection from large fish may be gained by batteries of long spines, as in the unusual Spiny Rock shell.

The aperture, or opening through which the animal projects when feeding and crawling is a weak spot which can easily let in the enemy. The Helmet shell and *Distorsio* and the unusual land shell *Polygyra* have their lips so twisted and armed with large interlocking teeth that the opening

is too small for most enemies to enter.

Rebuilding the Entrance

Of course, the entrance is now too small for the mollusk to grow larger if it remains, but the animal simply dissolves away the shell obstructing the opening, adds the additional shell growth and then closes it off again. Many shells have large ridges on the whorls, each revealing where such a former opening existed.

Shells With Doors

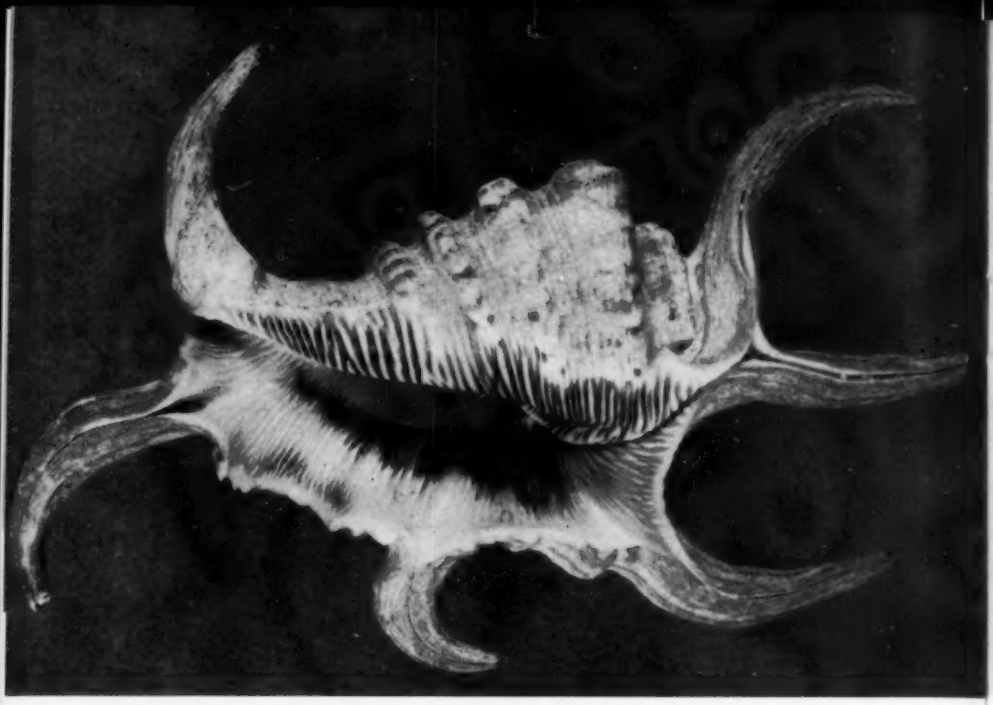
Some shells cannot close the opening by narrowing it with teeth and thick lips. Instead most have a horny or shelly door, or operculum, which plugs the opening when the animal withdraws into the shell. This not only keeps out marauders but also, if the mollusk lives above low water, retains moisture in the shell during exposure to the air. Not all mollusks with opercula can close their doors; some don't need to because they are big and active, or some, like the poison cone shells, have no fear of invaders. The Queen Conch, in fact, has developed a long pointed operculum that it uses for locomotion, hitching itself along the bottom like a man in a small boat with a boathook.

While thin shells may be strengthened by the addition of ridges and flutings, most mollusks just thicken the shell. There may be three reasons for this: (1) Protection from large animals which otherwise could crack or bore into the shell, (2) protection from the battering action of surf and waves and (3) in animals living between the tide marks as insulation from the heat of the sun's rays when exposed at low tide.

In addition to being shaped in different ways for protection alone, shells may have different shapes because they are then better equipped for living in rocks, burrowing through the sand, or hiding from enemies.

Toothshells which have nearly straight tube shells are not active but live half buried in the sand. They are small because with a straight or irregular shaped tube the animal must

A HELMET SHELL CUT IN HALF. *This section of Cassis shows a thick lip, indication that the growing period has ended (right). The other temporary lips built by the mantle at various intervals have been partially resorbed, to make living room within the house as the animal grew. (Walter R. Courtenay, Jr.)*



OCTOPUS TRAP. *Oriental fishermen use this shell, when empty, for catching octopus. The long spines serve partly for protection and partly for support in the soft bottom where the* Lambis chiragra *Linne dwells in the Indo-Pacific. Although it is quite different in appearance, it is closely related to the Queen Conch of the Florida Keys. (Walter R. Courtenay, Jr.)*

remain small or it cannot pull the shell around with it. Some other means of handling the shell must occur if the animal needs to crawl about.

Some gastropods have long irregularly twisted tubes which are completely unmanageable. *Vermetus,* a good example, is a mollusk which begins life with a neatly coiled spiral tube and full abilities to crawl or glide. But then, for some reason, the coiling becomes irregular and twists in wild disarray and the animal becomes sedentry, spending its life in one spot.

Actually most mollusks have shells tightly coiled around a central pillar so that the shell is compact and easily carried about by the soft parts of the animal. The shell may be round as in the cowries, covered with irregular spines for camouflage as in many rock shells, or long and slender such as the auger shells which are beautifully adapted for crawling beneath the surface of the sand.

Pick up a false limpet or *Siphonaria* with its simple saucerlike shell and look at it closely. On its back, if you have good eyesight you will see a few coils of the baby shell. This animal, as some others, was originally coiled like other snails but when it took up its home on exposed rocks it developed a large foot for holdings onto the rock surface and the shell

flattened out. Abalones or *Haliotis* show a similar last whorl which is large and open and equipped with a number of holes along one edge for water circulation.

Some mollusks do not need a shell to protect them. Instead, fishes shy away from them because they taste bad or may even sting. A shell is also a hindrance to those which are designed for swimming or fast movement. For example, sea butterflies of the plankton are delicate creatures with light transparent shells. They float in the upper layers of the sea. Along the shore the swimming sea slugs or sea pigeons or hares have only a vestigial internal thin horny shell which rests as a cap over the more easily injured internal organs.

Color Caused by Diet

Color in snail shells is layed down by special pigment secreting cells in the mantle when the shell is being formed. Possibly some of this may be inherited but, at least in certain colors, it may be due to effects of the surroundings.

Experiments carried out in England have shown that in one of the purple shells color is due to diet. Shells feeding on purple mussels formed purple shells and when feeding on white barnacles formed white shells. Yellow shells were formed in areas of greater exposure to sea and sun. Somewhat similar results have been found in others, such as cone shells. Whatever the cause, the variety is tremendous, but gaudiest of all shells in color are those from the Indo-Pacific. Why, we do not know.

Clams not as Glamorous

In contrast to the gastropods, the bivalve mollusks do not show such variety of form. Perhaps this is because most clams are stay-at-homes. Smooth or long thin shells are characteristic of burrowers because they can pass with little difficulty through sand and mud. *Anomalocardia* is an example of the first and the razor clam *Ensis* well represents the active sand and mud burrower. The shells of the shipworm or teredo have been greatly changed because the animal

SHELL UNTWISTS IN GROWTH. *The worm shell* (Vermicularia spirate Philippi) *begins life as a neatly-coiled gastropod, then suddenly goes astray, unwinds, and becomes sedentary, lying half buried in the sand. With such a distorted shell the animal would find itself at a great disadvantage over compactly-housed competitors if it had to search out its food. (Walter R. Courtenay, Jr.)*

lives in wood. In this animal, closely related to the common clam, the shell is a boring device and has sharp rasping edges for tearing away the wood. They are far too small to contain the long, worm-like body which, however, is fully encased by its wooden burrow.

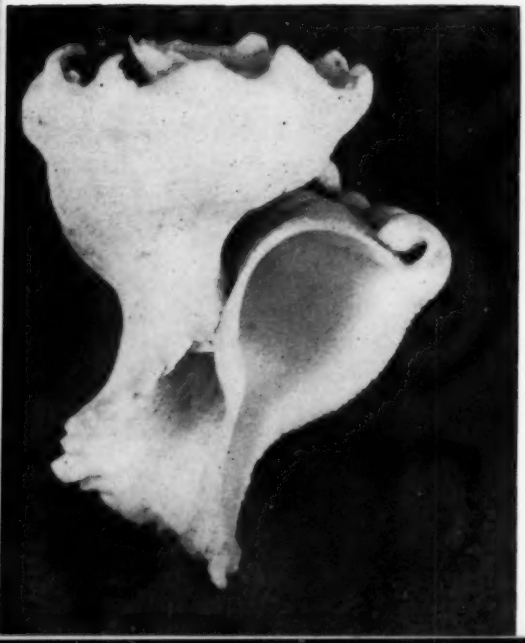
Often the non-burrowing mollusks live only half or slightly buried beneath the surface. Lacking mobility, they are in danger of being washed out and swept away by wave action. Anchoring is provided by heavy ribs and numerous spines which grip the sand and hold fast, except in the heaviest storms.

Bivalve Oddities

One of the oddities among bivalves is the watering pot shell or *Aspergil-*

AN ODD FELLOW *is the watering pot shell* (Brechites strangulatum *Chenu*) *which at first glance resembles a tube, with a sprinkler nozzle at one end (bottom). Note, however, two tiny shells of a typical bivalve near the base of the tube. (Walter R. Courtenay, Jr.)*

A JAPANESE KIMONO *is suggested by the loosely-coiled shell of the* Coralliophila deburghiae Reeve. *This snail occurs off the coasts of Japan. (Walter R. Courtenay, Jr.)*



lum. It begins its career as a normal bivalve but at an early stage opens its valves wide and forms a large tube 5-6 inches in length and open at one end, within which it lives, its bivalve nature revealed only by two tiny shells raised in bas relief near the base of the tube.

Even bivalves protect their entrance, in spite of the fact that they can tightly close in most cases. Such is the case in the giant clam shell *Tridacna* which can attain a weight of 500 pounds, and its smaller near relative *Hippopus*. *Tridacna* is known as the man eating clam from stories about pearl divers trapped by the toothed edge of the shell. Undoubtedly a pearl diver might be caught from stepping unwarily into a shell, but no authentic case is known to the writer.

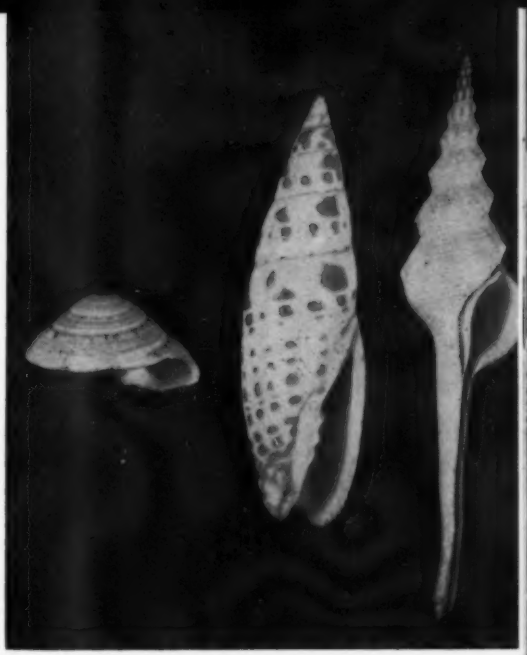
Living Anchors

The mussels, ark shells and others attach themselves strongly to the bottom by means of long tough threads or byssus. They live on hard objects such as rocks or pilings and their shells are often massive because of their sedentary habit. Oysters simply cement themselves to hard bottom by one shell and live there for the rest of their lives, although occasionally large ones break loose and are found lying free. Oyster shells may grow in varied form and sometimes veritable giants may be found.

Nature's Jets

Some bivalves, like the scallop or *Pecten*, actually swim through the water. In the scallop the shell is usually thin, but ridged for added strength. The animal swims in a jerky fashion by taking water into the mantle cavity and then expelling it in two jet streams, one on each side of the hinge. It is an unforgettable sight to see a grass bed covered by hundreds of these erratically jumping shells. It also affords a swift means of escape from the stealthy attack of starfishes.

Thus we see not only that shells are beautiful and unusual objects of nature but that they are an integral part of the animals which form them, giving them protection from enemies and the physical factors of their surrounding, and molded by habitat into the infinite variety of forms we see about us at the seashore.



SHORT AND TALL OF IT! *To the left is the depressed sun-dial shell* (Architectonica noblis *Roding), in the middle a mitre shell* (Terebra maculata *Linne), with a drawn out spine, and on the right a spingle shell* (Fusinus depetitthonarsi *Kiener), with both spine and siphon groove extended into a long tube. (Walter R. Courtenay, Jr.)*

OPEN AIR OPERATION *processes fish on the flats near Cay Glory. During the grouper run (December to February) fishermen work in teams to take care of the catch. After the fish have been dipped from the pounds behind the hut, three men butcher and split them, another soaks them in the water to clean them, and then passes the fish to a worker who makes deep cuts in the flesh so that more salt can be rubbed in. Finally, they reach the salters, at the left, and are stored in the thatched hut until they can be packed and shipped. (C. P. Idyll)*

Fishing and the Woodcutting Buccaneers

By C. P. IDYLL

OUR GUIDE WAS Ephraim Guerrero, chairman of the town council. He was showing us the neat fishing village of San Pedro, Ambergris Cay, British Honduras.

"There is one of our fishermen. Perhaps you would like to meet him, since you are interested in the seining. He and his son operate a beach seine, and catch bonefish and other shallow water species."

He pointed to a slight figure twenty yards or so offshore, securing a trim, white sailing boat. The fisherman was barefoot, with his pants rolled up, and he wore a straw hat. Presently he slipped over the side of the boat into a tiny dory and poled ashore.

"It is unusual for two fishermen to try to handle a beach seine without more help, but Valario Rosado here and his son do it nearly every day. By the way, he is 98 years old, and his 'boy,' Ynestrozo, is 68!"

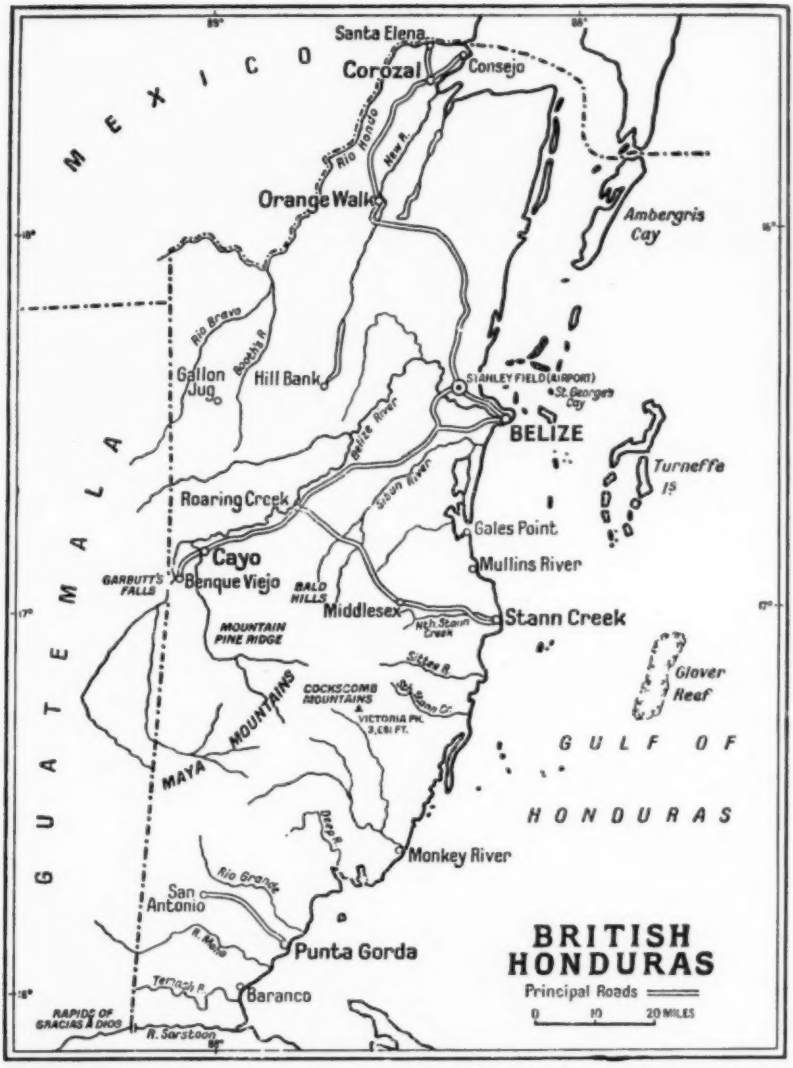
Earlier I learned that bonefish, much loved by anglers but not usually regarded as a food fish, are caught commercially and eaten by the natives of British Honduras. This was of interest, since it was one of the matters the Government of British Honduras had asked me to investigate.

Treasures in Timber, Too

British Honduras is tucked into a small notch of the Central American land bridge, between the Mexican Territory of Quintana Roo and the Republic of Guatemala. It is a British "island" surrounded by Latin countries, a little isolated politically and culturally. "BH," as the residents call it, was first settled by British buccaneers whose main purpose had been to make life miserable for the rich towns and shipping of the Spanish Main. Seeing treasure also in the mahogany and rosewood forests, some of the pirates settled at the mouth of the Belize River and began to exploit timber.

Repeated attempts by the Spanish authorities failed to dislodge the Englishmen, but the hostility and con-

VETERAN OF MANY A BATTLE with wind *and tide. Valario Bosado, 98-year-old fisherman of Ambergris Cay, still fishes regularly with a heavy beach seine. His 68-year-old son assists him. (C. P. Idyll)*



BRITISH HONDURAS IS TUCKED IN A CORNER *of the Caribbean between Mexico and Guatemala. Its long coastline, fed by scores of jungle streams, and its many offshore islands and reefs sustain an active fishing industry, but its fisheries potential has hardly been tapped, either for food or for angling. (Map from official sources)*

SPINY LOBSTER BUYER *for a freezing plant in Belize. Euphraim Guerrera, chairman of the town council of San Pedro, Ambergris Cay, served as guide for the author and David Bradley, Comptroller of Customs, on an inspection trip of his village. Beside him is a lobster trap and two live boxes to hold lobsters awaiting shipment. The* Lolette, *Customs Service patrol vessel, is anchored offshore. (C. P. Idyll)*

tinual pressure discouraged any tendency they might have had to develop agriculture. Partly as a result of this, the people of British Honduras import a great proportion of their food and, despite more than three centuries of settlement, the population of British Honduras is still only about 90,000, in an area double that of Jamaica, inhabited by 1,671,000. The areas offshore from BH are relatively large, but fishery resources are underdeveloped. It was to suggest how these resources might be put to better use by the country that I was there in February of 1961.

My companion at San Pedro, and on several other trips to various parts of the Colony, was David Bradley, the affable Comptroller of Customs, whose department administers the fisheries. We had chosen the little village on Ambergris Cay as our first port of call since it is a major center of fishing. Apart from the relatively minor seining operation, San Pedro residents carry on a sizeable fishery for spiny lobsters, or crawfish, and, during the winter, catch black groupers for the salt fish trade.

The spiny lobster as a commercial fishery has a short history. Before 1925, lobster was a staple food for people living near the coast. In that

HORDES OF CATFISH *lie in wait for the fish offal thrown into the Belize River. At the municipal market, in the center of the British Honduran capital city of Belize, fishermen remove their catches from the live wells in their boats and clean them on the counters at the right. Catfish constitute such an important sanitary facility that they are protected by city law. (C. P. Idyll)*

year a Massachusetts sea captain set up a cannery at Cay Caulker and showed the natives that there was money in this formerly lightly-regarded creature. But the fishermen, after a very few weeks, decided they had enough. What was the point of working hard to earn more?

Third Try a Success

So Captain Foote's experiment folded up in 1927 and the doughty New Englander brooded for ten years before he tried again. The result was the same, however, and the fishery lapsed back into the subsistence level of former times.

Another decade passed, and in 1946 a freezer ship arrived from Miami. Run by two Estonian Americans, Kou and Ahto Walter, the *Lucy* began to buy lobster on a sizeable scale. This was the real beginning of the spiny lobster industry of British Honduras, an industry which exported a million pounds of crawfish tails to the United States in recent years, and which has returned over $200,000 yearly of sorely needed hard currency to the colony.

"Bully Nets"

In the old days the fishermen caught crawfish with "bully nets,"

conical shaped nets on the end of a long pole. Capt. Foote and the Walter brothers taught them to use traps, first like those employed by the New England lobster fishermen, and later similar to types used by Florida lobstermen.

Traps are still favored by many fishermen, but the trend is now toward skin diving with a spear gun.

U.S.A. Best Market

With the exception of a small quantity exported to nearby Central American countries, nearly all the spiny lobsters caught in British Honduras are shipped to the United States. At 45 cents a pound for the tails, crawfish are too expensive for most local residents, even for the fishermen themselves to eat.

If there is some doubt whether the lobster stocks can stand greater fishing pressure, there is little question that the "scale fish" populations are being under-exploited. In the 174-mile coastline of the country, plus the great areas of fertile shallows off the coast, big schools of many kinds of high quality tropical fish occur. Spanish mackerel, groupers, snappers, mullet, tarpon, bonefish and dozens of different kinds of colorful reef fishes are abundant, and are not now fished heavily.

This light exploitation of fish stocks is due in part to the relative sparseness of the population, so that demand for fish within British Honduras is not large enough to support a big industry.

Nonetheless, in certain cays, fishing is not only the principal occupation but virtually the sole source of income. At Cay Calker, for example, every one of the 457 people makes all or nearly all his livelihood from fishing, and this applies even to the saloon-keeper.

Natural Trash Eliminators

With a few exceptions these boats carry their fish to market in live wells. Only in very recent years have a few lobster fishermen begun to carry ice. Since about a third of the population of British Honduras lives in Belize, the capital, most of the fishing boats are based there and bring their catch to the public market in the middle of town. This market is situated in an especially favorable location, since it is on the bank of the Belize River and the fishing boats can be drawn right up to the fish stalls.

The fish market has an automatic disposal system. When the offal from the fish cleaning operation is thrown into the river there is a frenzied boiling of the water and the garbage disappears like magic. A population of catfish, permanently resident in the river, have done their duty again. So vital are the catfish to the sanitation of the river that when an enterprising fellow brought in a seine some years ago, and began the profitable operation of catching the catfish for sale, a regulation was hurriedly enacted to make this illegal.

Salt Fish Industry

Most of the fish sold in the Belize market are shallow-water species, like mullet, grunts and barracuda. Some deeper water fishes, such as groupers, are sometimes sold as well,

but the greatest volume of the groupers do not find their way here. Instead they form the basis of an active salt fish industry. This is centered near Cay Glory, and David Bradley and I visited this area about a week after our trip to San Pedro.

Cay Glory is a tiny spot on the edge of the reef, between Belize and Stann Creek, closer to the latter. Five or six fishermen were on a small boat, nearly crowded off into the water by yellowish salted groupers drying in the sun, and by an enormous glass net float at least two feet in diameter, which had probably floated across the ocean from Portugal.

Unhappy Fishermen

The fishermen, we found, were in an unhappy mood. The weather had been unseasonably rainy and this had made it very difficult to dry their salted fish, requiring a frenzied turning of the fish skin-side-up at each of the frequent showers. Our visit was in mid-February and the crew had been anchored in this spot since December 22, with no return home for Christmas or any other time. "Home" was the village of Sarteneja ("Frying Pan") near the Mexican border.

During their long sojourn they had run out of most kinds of food, including all kinds of fats, coffee, sugar, milk and other staples. They were subsisting on boiled grouper and plate-sized tortillas, both cooked over a wood fire on the after deck of their vessel. Their cigarettes had long since disappeared, and to add to their woes the engine would not start.

Salteries Far from Shore

We took aboard our skiff two of the fishermen and headed toward the area where the groupers were being salted by a dozen or more crews. The nearest land was a considerable distance away, but this did not prevent salteries being established. The water here was only three or four feet deep, and sizable platforms had been constructed by driving poles in the bottom. Thatched roofs had been built over parts of the platforms and crews of six or eight men were salting down the big fish.

The fish used are called black grouper in British Honduras, and their dark hue certainly justifies this name. This is the same species, *Epinephelus striatus,* which we call the Nassau grouper in Florida. The ones we saw were big, handsome fish, averaging eight or ten pounds, with a dark brown and black mottled pattern and astonishingly scarlet linings to their mouths. The fisherman catch them in water ten fathoms or so deep over the edge of the shallows with hook and line gear. They carry them to empoundments beside their salting platforms and hold them alive.

Fish Production Line

The salting operation is a production line process. One man supplies the butcher with fish dipped from the pound. The fish are split down the back so that they can be laid out flat. The cleaned fish are tossed into the shallow water to allow the blood to seep out, and, after a few minutes of this soaking, a man in an anchored skiff passes them to a companion

HUNG UP LIKE WASHING, *salted groupers dry on racks in the yard of this fisherman living on Cay Caulker, British Honduras. The fish were caught and salted near Cay Glory, and brought by boat to Cay Caulker for final preparation for shipment to Puerto Barrios, Guatemala, and other markets. (C. P. Idyll)*

who makes deep scores in the flesh with a sharp knife. Next, the salter rubs as much salt into the flesh of the grouper as possible. This done, the fish are laid out on platforms to dry in the tropical sun.

Luckily Precedes Lent

The British Honduras grouper run comes at an opportune time. It starts some time in December and lasts into February or a little later. This precedes the Lenten season just far enough to permit the fishermen to take advantage of the strong market for fish which then exists in Roman Catholic countries.

One nation which observes this custom strongly is Guatemala, and another is the Republic of Honduras. Both near neighbors of British Honduras, they buy considerable quantities of salt fish from the Colony. In fact, BH fishermen can sell any quantity of this product that they have so far been able to produce, and the trade through Porto Barrios, the main port of entry into Guatemala, is brisk in the pre-Lenten period.

Any degree of quality, too, will apparently be accepted. An experiment some years ago to improve the salt fish produced in British Honduras failed because it involved a longer, and therefore more expensive process, which did not return the

fishermen any greater income than the old, quick method. Guatemalans like their salt fish strong-flavored, and show a decided preference for snook. Honduranians, on the other hand, pay higher prices for the milder-flavored jacks.

Now Frozen Fillets, Too

In several of the fishing villages in the coastal areas of British Honduras we saw great stacks of salted fish being accumulated for shipment. There are signs that other fishery products may become more important, however, since small quantities of frozen fillets of these same groupers and of snappers and other fishes, are beginning to be shipped to Puerto Rico, Jamaica and the United States. This trade promises to grow considerably in volume as markets are encouraged.

Trade in conch, another fishery product which up to now has been of minor importance, also shows indications of expanding. Most people know conch only for its attractive shell, which they see in curio shops or on the mantle or the hearth at home. But conch is a principal item of food for many people, for example in the Bahamas, and many a tourist to those and other islands of the Caribbean have found to their surprise that conch chowder or raw conch salad are gastronomic delights. Small quantities of conch are exported from British Honduras to the United States and there will be larger amounts in the future.

An interesting local "resident" thinks highly of conch. Approaching Belize from St. Georges Cay during my trip, I saw a porpoise, the sportive mammal that delights sailors with its graceful swimming, roll to the surface of the water with a conch in its mouth. This is a favorite food of the porpoise, according to the local fishermen, who say that it sucks the meat directly from the conch shell.

EVER SEE A REAL "MOCK TURTLE?" *The author holds one made of mahoghany and used as a decoy by fishermen of British Honduras to lure turtles into their nets. Found on a deserted beach near Tobacco Cay, its design and skillful carving make it a real primitive* objet d'art. *(C. P. Idyll)*

A Real "Mock Turtle!"

In common with many other countries of the Caribbean, British Honduras once had a considerably larger turtle population than it does at

present, but fishing has reduced this. Turtles have been caught by several methods but perhaps the most interesting is with tangle nets. These are large meshed nets set vertically in the water. Often a turtle decoy is attached to the net, this being a cleverly shaped "mock turtle" made of cedar or mahogany, suspended from the net by a line strung through a hole near the tail.

I picked up a partly finished turtle decoy on the beach at Tobacco Cay, deserted at the time of our visit except for a lonely little dog. I was pleased later when I sanded down the surface, to find that my turtle was made of mahogany. Its design and skillful carving make it a genuine primitive *objet d'art.*

An attempt is being made to re-establish the turtle populations to their former level by planting young turtles in some of the keys. Green turtles have been sent from the hatchery at Tortuguero, Costa Rica, by Archie Carr, herpetologist of the University of Florida. The young turtles have been released at the Northern Two Cays and other offshore islands. More of that epicure's delight, green turtle soup, may result from this activity.

176 Pound Tarpon

The sea supplies sport as well as food, and the game fishes of British Honduras promise to be among the principal assets of the country. These waters have been so lightly fished that hooks are quickly grabbed. Bottom fishing for snappers and grunts and many other species is good, while there are Spanish mackerel and kingfish for trollers. In the "blue water" outside the reef, sailfish and marlin have been caught in recent years.

Fishing for the latter is so new that the number caught in the British Honduras can be counted on the fingers. But they are there for those with the proper boats and gear. Deep-sea fishing boats can now be hired out of Belize to fish the reef areas as well as the "blue."

None of these excites the sportsman in BH as much as the pursuit of tarpon and bonefish. British Honduras has some of the best fishing for these species in the world, and old-time fishermen who have seen some of the richest grounds elsewhere get excited when they talk about their experiences in British Honduras.

The largest tarpon caught there weighed 176 pounds. A veteran guide, Vic Barothy, has done more to open up sport fishing in British Honduras than anyone else. Barothy started his career in Michigan, then guided "sports" out of Marathon in the Florida Keys, followed by ten years in the rich areas of the Isle of Pines in Cuba. He has been established in Belize for two years and takes parties to the various fishing grounds on commodious house boats.

The Government of British Honduras is aware of the value of its fisheries resources. A great many other people, those who like to eat fish and those who like to catch them alike, are going to become increasingly aware that this little country exists, and that it has abundant fish for both purposes.

WHERE THE BLUE CRAB *normally dwells. In the Virginia and Maryland waters of Chesapeake Bay the blue crab is sometimes caught and placed in floating wooden boxes to await shell-shedding, a convenient and simple way of obtaining soft-shell crabs for market. (Virginia Chamber of Commerce)*

How Did It Get There?

One of the most familiar and delectable of American seafoods is the blue crab, which boils out a bright red for the dinner table. The earliest pioneers found it had long been relished by the Indians. Chefs later discovered the blue crab could be prepared in exotic dishes to tickle the palates of fishermen and gourmets alike.

For many years the blue crab was thought to live only along the eastern seaboard of North America, but in 1930 Rathbun gave it a range from Nova Scotia to Uruguay and the Bermudas. In 1901 Bouvier had already noted its accidental occurrence in fresh water at Rocheford, France.

Like some other American marine emigrants, such as the American oyster and the slipper shell, the blue crab (*Callinectes sapidus* Rathbun) has

now become fairly entrenched in the Mediterranean. In 1948, it first appeared in Greece's Aegean Sea, then spread to the northeastern coast of Greece, where it is already being exploited by alert fishermen.

Now Mr. Christos Serbetis, of the fisheries research laboratory of the Ministry of Industry, Greece, declares that the blue crab has gone even further afield. In a report to the General Council, Food and Agriculture Organization of the United Nations (FAO), at Rome, he states that the wanderer has for some years been established along the coasts of Egypt and Lebanon.

Biologists still do not known how this "beautiful swimmer," as *Callinectes* means, became introduced into these far Mediterranean waters. Perhaps European readers of *Sea Frontiers* may have the answer.

EVERYONE ALONG THE EASTERN SEABOARD *of North America will recognize this as the common blue crab, but biologists are puzzled about its recent appearance in the Mediterranean, where it has become well entrenched in Greece's Aegean and already is being exploited by alert fishermen. There are reports, too, of catches along the coasts of Egypt and Lebanon.*

Technologists' Place In Fisheries

"TECHNOLOGY does not play the part in fisheries that it should—it is under-appreciated, not understood, under-utilized, and probably under-paid," said Thomas Fulham, President of the Boston Fish Market Corp., to the New England Fisheries Technologists at a recent meeting held at the Boston City Club.

Giving management's viewpoint on the technologists' place in the fisheries industry, Fulham said further: "Management today realizes the necessity for technological help more than at any time in its history. With such a feeling it is only logical to conclude that the technologist will move into his rightful place as the appreciated and trusted advisory to management."

Technologists have, however, done some outstanding work in recent years, Fulham pointed out. As an example, the fields of cooking fish and fish sticks, and the processing of fish meal have shown admirable progress. Management fails too, he said, when it fails to seek the advice and guidance of the technologist. Much remains to be done to maintain quality of fish in the handling between the time it is caught and processed. Management and the technologist must jointly seek the solution.

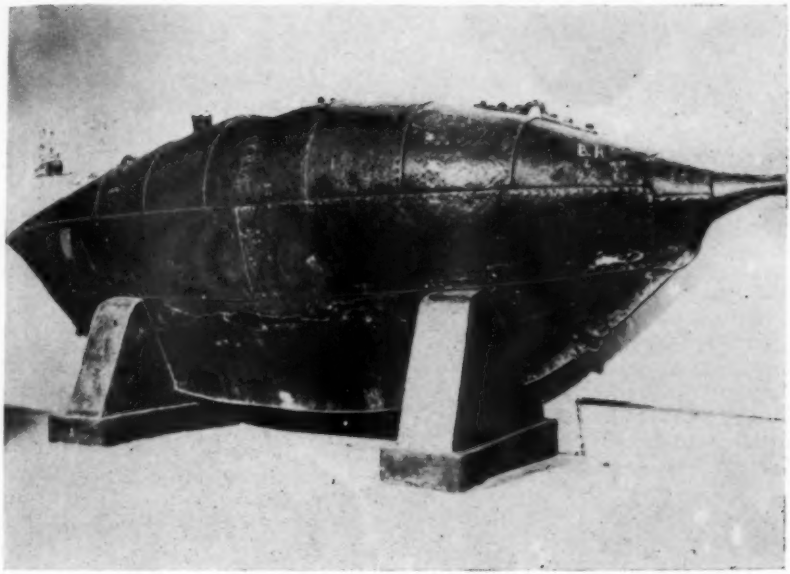
Ernest Hemingway

In the death of Ernest Hemingway, on July 2, 1961, the International Oceanographic Foundation lost one of its most valued members and a long-time trustee. In addition to being a Nobel prize-winning author and a pioneer game fisherman, Mr. Hemingway was genuinely interested in the conservation of pelagic or open sea fishes, and believed that the danger of reducing certain game fish populations by overfishing could be minimized by encouraging anglers to release their catch as soon as it came to boat.

With several other game fishermen and writers on marine subjects, he early recommended the giving of competition points in tournaments for each fish released, a measure which was eventually adopted. In the Sailfish Derby of 1956, for instance, of 626 fish caught in twenty-eight days, 507 were released, an 82% score. Mr. Hemingway recognized this sporting gesture by offering an autographed copy of his famous novel *The Old Man and the Sea*, with trophy bookends, as one of the prizes awarded in the Derby.

Erl Roman, an I.O.F. trustee and former fishing editor of the *Miami Herald*, accompanied Hemingway on many of his fishing trips and served with him in several international game and fish organizations. "Back in 1935," Roman recalls, "Hemingway was the first angler to catch a bluefin tuna in the Bahamas. This was a magnificent accomplishment in the days of few charter boats, primitive fishing gear, and unsure guides."

Through his many dramatic stories of fishing, fishermen and the life of the sea, Mr. Hemingway will be remembered with gratitude by millions as one of the very special patron saints of anglers. While Isaac Walton appealed to the meditative devotee of quiet streams and light tackle, Hemingway will be revered by the robust open-sea sportsman who likes to fight hundreds of pounds of finned fury with enormous gear, the skilled maneuvering of an experienced boat captain, and the encouragement of seagulls screaming in his ears. Marine scientists and oceanographers will remain in his debt for focusing the interest and the curiosity of the average layman on some of the thrills, wonders, and abiding mysteries of our sea frontier.



DESPERATE INVENTION *of the Confederates. The submarine* Pioneer, *is now in the Louisiana State Museum. She was never successful and, in fact, drowned several of the hardy souls who attempted to man her. (From* Challengers of the Deep)

Science of the Sea in BOOKS

General Reading

CHALLENGERS OF THE DEEP

WILBUR CROSS. William Sloan Associates. New York. 1959. 173 pages. Illustrated. $5.

Since the close of World War II, a number of informative and exciting books have been written about the exploits of both Allied and Axis submarine fighting forces. Mr. Cross brings the story of the "silent service" up to date, including the long and bitter backstage fight to put the atom underseas. This is a dramatic, thought-provoking book, particularly in view of the threat poised by Soviet Russia, which has the world's largest submarine fleet. The modern submarine is a remarkable craft in that it involves the application of the atomic and oceanic sciences, as well as the psychological and physiological. Or, as a retired Admiral remarked, "The most amazing thing about the new atom subs is the men who man them!"

E.J.L.

THERE'S ADVENTURE IN MARINE SCIENCE

JULIAN MAY. Popular Mechanics Press, Chicago, Illinois. 1959. 160 pages. $2.95.

Though aimed at a teen-age audience,

this well-illustrated volume will also be of interest to grown-ups who may be afraid to expose their ignorance of marine biology and other basic scientific matters related to the sea. While the text employs dialogue and fictional approaches to the marine sciences, the illustrations quite accurately portray currents, plankton and other sea life, and some of the tools of modern oceanographic research. The book tells also how boys and girls can find an exciting career in oceanography, one of the least crowded but most vital sciences today. E.J.L.

THE GREAT BARRIER REEF AND ADJACENT ISLES

KEITH GILLETT AND FRANK MCNEILL. Coral Press Pty, Ltd., Paddington, Sydney, Australia, 1959. i-xiii, 194 pp. 27 color plates, and 134 black and white photographs. 70 shillings in Australia ($9.80).

The Great Barrier Reef of Australia, the world's most renowned coral tract, extends for 1,200 miles along the northeast coast of Australia, to lose itself in the Coral Sea. First discovered by Capt. Cook in 1770, the maze of brightly colored corals has been visited by a long series of zoologists and oceanographers. In 1893 Saville Kent published his treatise on the Great Barrier Reef, illustrated with photographs and gaudy colored plates, and in 1930 C. M. Yonge gave us his fine "A Year on the Great Barrier Reef." These and many others are good, but the present work by Gillett and McNeill, by means of the exquisite color and black and white photographs and detailed writing, comes closer to presenting the reefs in all their color and glory than any other work.

Gillett's photography is superb, unequalled in its kind and the illustrations alone are worth the price of the book many times over. Many photographs are unique, presenting living animals in their native haunts for the first time. Amateur photographers will also appreciate the appendix with much valuable advice on how to take underwater photographs. G.L.V.

MARINE SHELLS OF THE WESTERN COAST OF FLORIDA

LOUIS M. PERRY AND JEANNE S. SCHWENGEL. Paleontological Research Institution, Ithaca, N. Y., 1955. 198 pages and 55 plates, index. Paperbound, $6.00; clothbound, $7.00, plus postage.

This is a revision of Dr. Perry's familiar *Marine Shells of the Southwest Coast of Florida*. This revision should be welcomed by every collector and student of marine shells. G.L.V.

SHIPS AND AIRCRAFT OF THE U. S. FLEET

JAMES C. FAHEY. Ships and Aircraft, Falls Church, Virginia. 64 pages. Seventh Edition, 1958. $2.50.

Few laymen have any conception of the size and diversity of the United States Navy. Nor, for that matter, do many Navy men. Mr. Fahey's useful little volume, the first edition of which appeared in 1939, therefore serves a dual purpose. Although it is privately printed, it is the most complete and concise reference book of its kind, and a handy thing to have around both the offices of the Navy, or of anyone dealing in maritime affairs. E.J.L.

A LIST OF COMMON & SCIENTIFIC NAMES OF FISHES FROM THE UNITED STATES AND CANADA

2nd Edition, 1960. American Fisheries Society, Special Publication No. 2. $1.00 paper, $2.00 cloth. Ann Arbor, Michigan.

A committee of seven ichthyologists has completely revised the earlier list of common names, extending the total entries from 570 to 1892.

Since the same fish may be known in different parts of the country by different common names or different fishes may be called by the same common name, any effort such as this to bring about a uniform usage is valuable to both scientist and angler. This list includes an index with many of the alternative names that have been used. It gives in each case a preferred common name based upon what appear to be sound and adequate criteria. Unfortunately, names that have been quite widely used are not listed in all cases. For instance, those who have used the term "Allison Tuna" will not find it in the index. Even though this name is not preferred, its inclusion in the index would help to clarify the situation for its former users.

It is hoped that this list will be given a wide circulation and thus help to dispel the confusion that has always been associated with common names of fishes. F. G. W. S.

Technical Reading

GENERAL METEOROLOGY

HORACE ROBERT BYERS. McGraw-Hill Book Company, Inc., 1944. 645 pages, (published formerly under the title of *Synoptic and Aeronautical Meteorology*).

This general text book was published fifteen years ago and covers all essential elements of weather analysis and weather predictions. It is based on a fusion of dynamic and synoptic meteorology, with a theoretical treatment of weather forecasting. The book is not very advanced in theory and does not include the most modern trends of development in meteorology to a general physics of the air. However, the book is excellent for giving the basic tools for the understanding of the weather and the processes governing it. F.F.K.

PRINCIPLES OF STRATIGRAPHY

CARL O. DUNBAR AND JOHN RODGERS. John Wiley and Sons, New York. 1957. 356 pages, $10.00.

According to an old cliché, the layers of sedimentary rocks which cover much of the earth's surface are the pages in which the history of the earth is written, and the fossils are the letters. Dunbar and Rodgers have brought this faded cliché to life. In a modern, up-to-date, and thoroughly authoritative textbook they review the processes by which both marine and continental sediments are being deposited today in the available variety of geologic settings (93 pages), and then pass to interpret the main types of ancient sedimentary rocks in the light of this knowledge (88 pages.)

In addition, the physical bulk properties of sedimentary rocks (stratification, stratification breaks, lateral changes in facies, etc.) and the significance of their fossil content are discussed in detail (61 pages.) The petrology of sedimentary rocks, extensively treated in Pettijohn's textbook, is summarized in a few pages.

PRINCIPLES OF FISHERIES DEVELOPMENT

C. J. BOTTEMANNE. North-Holland Publishing Co., Amsterdam, 1959. 677 pages. $12.00.

Dr. Bottemanne's voluminous work entitled *Principles of Fisheries Development* will be a good reference work on the shelf of anyone interested in promoting the welfare of commercial fisheries. Heavily weighted on the economic side, it errs, perhaps, in its unqualified acceptance of some theories of fishery dynamics. It is also too detailed and repetitive for easy reading or reference, but its completeness reflects the wide experience of the author in varied kinds of fisheries and this fault is outweighed by the virtues of the book. C.P.I.

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